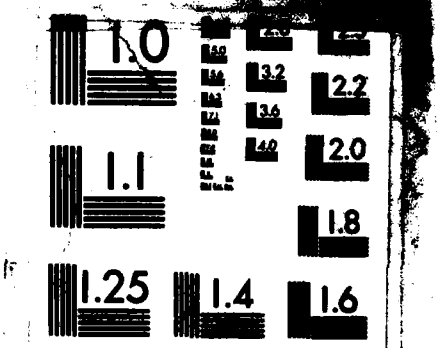
AD-A157 286 FARGO-MOORHEAD URBAN STUDY WATER CONSERVATION APPENDIX 1/3
(U) CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT
MAY 85

UNCLASSIFIED F/G 13/2 NL



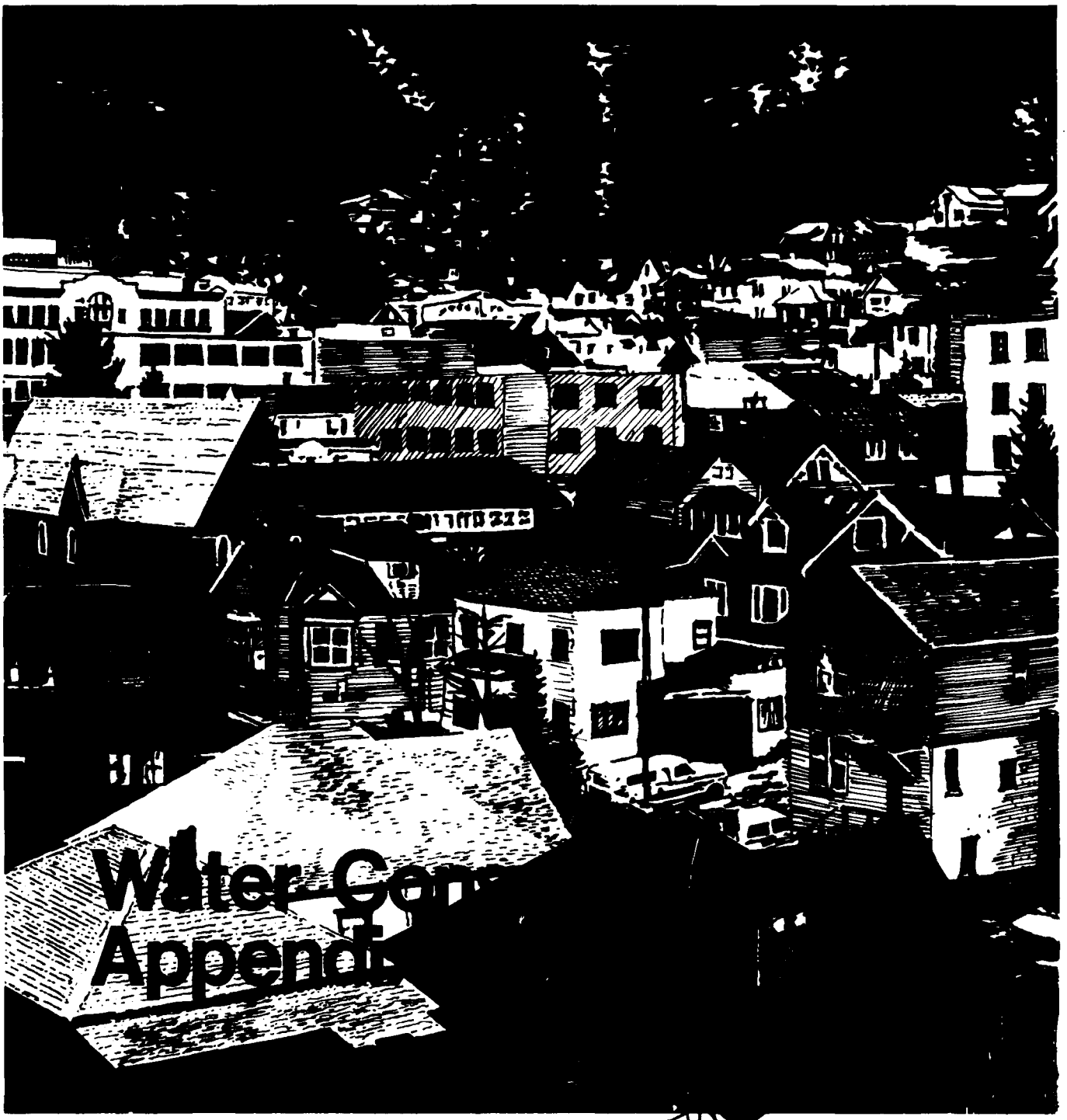
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD-A157 286

US Army Corps
of Engineers
St. Paul District

May 1985

(2)



Water Ge
Append

DTIC FILE COPY

This document has been approved for public release and sale; its distribution is unlimited.

85 7 15 066

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A157286	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) FARGO-MOORHEAD URBAN STUDY; Water Conservation Appendix.		5. TYPE OF REPORT & PERIOD COVERED FINAL, ~~1980-2030~~
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Eugene A. Hickok and Associates		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St Paul 1135 USPO & Custom House St Paul, MN 55101		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE May 1985
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Issued in several parts: Summary Report; Background Information Appendix; Water Supply Appendix (3 volumes); Water Conservation Appendix; Energy Conservation Appendix; Flood Control Appendix; Water Resources Data Management System: a users manual.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

URBAN PLANNING,
FARGO (NORTH DAKOTA),
MOORHEAD (MINNESOTA),
WATER CONSERVATION.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Fargo-Moorhead Urban Study is a cooperative Federal, State and local planning effort aimed at developing viable solutions to water and related land resource problems, needs and concerns for 1980-2030.

The summary report contains a brief, non-technical overview. Readers desiring additonal detailed information should review the appropriate technical appendixes.

This study initially considered all common methods of conservation. These

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

water conservation measures were then evaluated and selected measures were incorporated into the most cost-effective water supply plan developed in phase 2. The benefits of water conservation were measured using the effect they have on the National Economic Development (NED).
NED benefits include reductions in the costs assoicated with a particular water supply plan and savings in the energy bills of individual consumers. In addition, conservation preserves existing water resources and augments supplies for future municipal growth. key words: [illegible]

FARGO-MOORHEAD URBAN STUDY

WATER CONSERVATION APPENDIX

St. Paul District, Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101-1479

MAY 1985

Accession For
NTIS GRA&I
DTIC TAB
Unannounced
Justification
By
Distribution/
Availability Codes
Dist | Avail and/or Special
A-1

DTIC COPY INSPECTED 3

PREFACE

The Fargo-Moorhead Urban Study was sponsored by the St. Paul District, Corps of Engineers, as a cooperative effort of local, State, and Federal agencies. The results of this study are contained within the following documents:

- Summary Report
- Background Information Appendix
- Water Supply Appendix (3 Volumes)
- Water Conservation Appendix
- Energy Conservation Appendix
- Flood Control Appendix
- Fargo-Moorhead Water Resource Data Management System Appendix (3 Volumes)

The Summary Report contains a brief, non-technical overview of the results of the overall study. Only readers desiring additional detailed information should review the appropriate technical appendixes.

TABLE OF CONTENTS

		Page
I.	SUMMARY	1
II.	INTRODUCTION	5
III.	WATER CONSERVATION MEASURES	8
	A. POSSIBLE MEASURES	8
	1. Metering	8
	2. Meter Maintenance	8
	3. Pressure Regulation	9
	4. Leak Detection and System Maintenance	9
	5. Pricing	9
	6. Economic Incentives	10
	7. Water-Saving Devices	10
	8. Industrial Process Modifications	11
	9. Re-Use of Municipal Wastewater Effluent	11
	10. Re-Use of Municipal Process Water	12
	11. Federal and State Regulations	12
	12. Local Codes and Ordinances	12
	13. Restrictions Rationing Use	13
	14. Restrictions Determining Priority Use	13
	15. Education Measures	13
	B. CURRENT AND PLANNED WATER CONSERVATION MEASURES	13
	1. Metering	14
	2. Meter Maintenance	14
	3. Leak Detection and System Maintenance	15
	4. Pricing	15
	5. Water-Saving Devices	17
	6. Industrial Process Modifications	18
	7. Re-Use of Municipal Process Water	18
	8. Federal and State Regulations	19
	9. Local Codes and Ordinances	25
IV.	IDENTIFICATION OF POTENTIAL MEASURES	27
	A. GENERAL	27
	1. Applicability	27
	2. Technical Feasibility	28
	3. Social Acceptability	28

TABLE OF CONTENTS (continued)

		Page
B.	ANALYSES OF INDIVIDUAL MEASURES	31
	1. Metering	31
	2. Meter Maintenance	31
	3. Pressure Regulation	31
	4. Leak Detection and System Maintenance	32
	5. Pricing	33
	6. Economic Incentives	34
	7. Water-Saving Devices	34
	8. Industrial Process Modifications	35
	9. Re-Use of Municipal Wastewater Effluent	35
	10. Re-Use of Municipal Process Water	37
	11. Federal and State Regulations	37
	12. Local Codes and Ordinances	37
	13. Restrictions Rationing Use	40
	14. Restrictions Determining Priority Use	40
	15. Education	40
C.	SUMMARY OF IDENTIFICATION ANALYSES	41
V.	POTENTIAL WATER CONSERVATION MEASURES	49
A.	METERING	49
B.	METER MAINTENANCE	50
C.	LEAK DETECTION AND SYSTEM MAINTENANCE	51
D.	PRICING	52
E.	ECONOMIC INCENTIVES	55
F.	WATER-SAVING DEVICES	56
G.	INDUSTRIAL PROCESS MODIFICATIONS	58
H.	LOCAL CODES AND ORDINANCES	59
I.	RESTRICTIONS RATIONING USE	61
J.	RESTRICTIONS DETERMINING PRIORITY USE	62
K.	EDUCATION	63
L.	SUMMARY OF POTENTIAL WATER CONSERVATION MEASURE IMPLEMENTATION CONSIDERATIONS	63

TABLE OF CONTENTS (continued)

		Page
VI.	EFFECTIVENESS EVALUATIONS OF POTENTIAL MEASURES	67
	A. SUMMARY OF DISAGGREGATED WATER DEMANDS	67
	1. Methodology of Disaggregated Forecasts	67
	2. Summary of Disaggregated Forecasts	69
	B. REPORTED EFFECTIVENESS OF POTENTIAL MEASURES	72
	1. Metering	72
	2. Meter Maintenance	73
	3. Leak Detection and System Maintenance	74
	4. Pricing	75
	5. Water-Saving Fixtures	76
	6. Retrofit Distribution	77
	7. Retrofit Distribution and Installation	78
	8. Sprinkling Ordinances	79
	9. Education	79
	C. POTENTIAL MEASURES' EFFECT ON PROJECTED WATER USE	80
VII.	MEASURE-SPECIFIC EFFECTS	87
	A. ADVANTAGEOUS EFFECTS	87
	1. Energy Savings	87
	2. Additional Economic Effects	91
	3. Environmental and Social Effects	91
	B. DISADVANTAGEOUS EFFECTS	96
	1. Implementation Costs	96
	2. Environmental and Social Effects	101
VIII.	OTHER EFFECTS	103
	A. FOREGONE SUPPLY COSTS	103
	1. Short-Run Incremental Costs	105
	2. Long-Run Incremental Costs	109
	B. FOREGONE EXTERNAL OPPORTUNITY COSTS	118
	C. FOREGONE NED BENEFITS	121
	D. IMPACT ON NEGATIVE ENVIRONMENTAL AND SOCIAL EFFECTS	121
IX.	SUMMARY OF WATER CONSERVATION MEASURE EVALUATION (includes Measure-Specific Effects)	123

TABLE OF CONTENTS (continued)

		Page
X.	WATER CONSERVATION PROPOSALS	127
	A. GENERAL	127
	B. PROPOSAL FOR URBAN CORE COMMUNITIES	129
	1. First Trial	129
	2. Second Trial	129
	3. Third Trial	129
	4. Fourth Trial	130
	5. Fifth Trial	131
	6. Sixth Trial	131
	C. PROPOSAL FOR RURAL COMMUNITIES	132
	1. First Trial	132
	2. Second Trial	132
	3. Third Trial	134
	4. Fourth Trial	134
	5. Fifth Trial	135
XI.	INTEGRATED WATER SUPPLY/CONSERVATION PLAN	137
	A. GENERAL	137
	B. EFFECTIVENESS	140
	C. ECONOMIC ADVANTAGES AND DISADVANTAGES	142
	D. IMPACT ASSESSMENT	146
XII.	DROUGHT EMERGENCY PLAN	150
	A. GENERAL	150
	B. EVALUATION OF CONTINGENT WATER CONSERVATION MEASURES	151
	C. DROUGHT EMERGENCY PLANS	157
	1. Drought Emergency Plans for the Urban Core Communities	157
	2. Emergency Water Supply Plan for Rural Communities	166
XII.	CONCLUSIONS AND RECOMMENDATIONS	172
REFERENCES		177
APPENDICES		

LIST OF TABLES

Table		Page
1	Federal Agency Programs Related to Water Conservation	20
2	Major State Water Conservation Programs	23
3	Attitudes Toward Common Water Conservation Measures	30
4	Potential Water Conservation Measures - Urban Core Communities	42
5	Potential Water Conservation Measures - Rural Communities	45
6	Implementation of Potential Water Conservation Measures	64
7	Summary of Disaggregated Water and Wastewater Use - Urban Core Communities	70
8	Summary of Disaggregated Water and Wastewater Use - Rural Communities	71
9	Average Percentage Reductions in Water Use and Sewer Flow	82
10	Effect of Water Conservation on Water Use and Sewer Flows	83
11	Energy Savings for Each Affected Conservation Measure	90
12	Possible Environmental and Social Impacts of Potential Water Conservation Measures	92
13	Summary of Implementation Costs	97
14	Critical Dimensions of Water Use for Supply Costs	106
15	Incremental Costs - Urban Core Communities	108
16	Summary of Foregone Supply Costs - Urban Core Communities	119
17	Summary of Foregone Supply Costs - Rural Communities	120
18	Summary Evaluation of Water Conservation Measures - Urban Core Communities	124
19	Summary Evaluation of Water Conservation Measures - Rural Communities	126
20	NED Merit Order Ranking of Measures Eligible for Water Conservation Proposals	128
21	Summary Evaluation of Water Conservation Proposals - Urban Core Communities	133

LIST OF TABLES (continued)

Table		Page
22	Summary Evaluation of Water Conservation Proposals - Rural Communities	136
23	Outline of Integrated Water Supply/Conservation Plan	139
24	Effectiveness of Selected Water Conservation Proposals	141
25	Integrated Water Supply/Conservation Plan Detailed Cost Estimates	143
26	Integrated Water Supply/Conservation Cost Savings	147
27	Effect of Conservation on Red River Flows	149
28	Potential Contingent Measures	152
29	Drought Emergency Plan - Urban Core Communities	159
30	Drought/Emergency Conservation Plan Penalties	165
31	Emergency Water Supply Plan - Rural Communities	167

LIST OF FIGURES

Figure		Page
1	Fargo-Moorhead Study Area	6
2	Water Treatment Plant Expansion Costs	112
3	Wastewater Treatment Plant Expansion Costs	114
4	Buffalo Aquifer Expansion	115
5	Storage and Piping Expansion Costs	117
6	Integrated Water Supply/Conservation Plan Capital Outlays	145
7	Drought Action Organization Chart	158

I. SUMMARY

In response to local concerns about future water supplies, the U.S. Army Corps of Engineers sponsored a water supply/conservation investigation as part of the Fargo-Moorhead Urban Study. This report describes the work done in Phase 3 of the three-phase investigation by Eugene A. Hickok and Associates under contract to the Corps of Engineers. Locally, guidance came from the Fargo-Moorhead Metropolitan Council of Governments' Water Resources Committee. Background preparation for this report also included a review of a vast amount of recent literature to document the probable impacts of water conservation on the 18 study area communities.

This study initially considered all common methods of conservation. These water conservation measures were then evaluated and selected measures were incorporated into the most cost-effective water supply plan developed in Phase 2. The benefits of water conservation to study area communities were measured using the effect they have on the National Economic Development (NED). NED benefits include reductions in the costs associated with a particular water supply plan and savings in the energy bills of individual consumers. The net annual NED benefits of the integrated plan after implementation costs are more than $1,600,000. In addition, conservation preserves existing water resources and augments supplies for future municipal growth.

This study maintains a distinction between the urban core communities of Fargo, Moorhead, West Fargo, and Dilworth and the other rural communities. Different conservation measures are proposed for each of these two groups of communities after applying several screening criteria. All communities are credited for existing conservation efforts and possible measures that duplicate existing efforts are eliminated from consideration. Conditions that may impede

successful implementation of measures are mitigated in individual implementation plans. Retained conservation measures are judged to be: applicable to water uses occurring in the study area, capable of producing measurable reductions, and socially acceptable to the residents of the area. Significant adverse environmental impacts were not considered acceptable.

Measures that meet these criteria and have benefits that exceed associated costs were combined to form different water conservation proposals. The proposal that offered the greatest net benefits to the urban core communities was composed of the following measures:

- Retrofit distribution and installation
- Pricing
- Education
- Sprinkling ordinance

These measures are ordered according to the value of their net economic benefits. The effectiveness of this proposal is shown by the 3.37 mgd (5.21 cfs), or approximately 13 percent, reduction in average annual demand.

This conservation proposal has significant economic benefits for the urban core communities. These benefits are primarily attributable to energy savings and foregone supply costs. Energy savings, primarily due to reduced hot water use, amount to more than $924,000 annually over the study period. Foregone supply costs from postponed, scaled-down, or eliminated water and wastewater facilities amount to more than $875,000 in annual savings. Major components of these savings include postponed water treatment and wastewater treatment plant expansions, reduced chemical treatment and power costs, and scaled-down aquifer development. In addition, the reservoir behind the low-head dam on the Red

River would not need to be raised. Implementation costs -- mainly for retrofit devices and installation, rate studies, and preparation and distribution of educational material -- reduce net savings for the urban core to $1,630,100.

Potential environmental and social impacts include increased water rates and reduced wastewater return flows. Potential increases in water rates would probably result from the implementation of a peak pricing for periods of heavy use. However, the size of this potential increase is site-specific and would need to be determined for each municipality by a separate rate study. Therefore, this effect is not presently quantifiable.

Conservation could reduce return flows from the urban core communities to area rivers by 2.29 mgd (3.55 cfs) in year 2030. This represents a reduction of less than 12 percent in the average return flows and the associated impacts are anticipated to be minimal.

The conservation proposal that offered the greatest net economic benefits to the rural communities was composed of two measures: retrofit distribution and installation and peak demand pricing during the season of heavy use.

This conservation proposal offers limited economic benefits because the savings in foregone supply costs are minimal. The fire flow requirements diminish the effect that conservation reductions have on the scale or timing of water facilities and limit potential benefits. The net annual NED benefit is $30,100. The Cass Rural Water Users Association customers will have more significant savings from reduced water bills because their cost of water is much greater. However, the latter savings are benefits to individual customers and costs to the CRWUA. Therefore, the effect is local and not a component of the NED account. Thus, the savings in water bills were not quantified. A potential social impact is the increase in water rates resulting from the implementation of the pricing measure.

It is recommended that all study area communities adopt drought emergency plans. These plans are able to extend the capability of the water supply/conservation plan beyond the 100-year event. This type of contingency planning is inexpensive and serves as an efficient means of dealing with drought shortages or contamination; without a plan, responses are crisis-oriented and often involve a series of hasty and controversial decisions.

The smaller communities could particularly benefit from having an emergency plan in place. Under present supply conditions, many rural communities lack auxiliary pumps or wells, as well as enough storage to meet their full fire demand. Under these conditions, shortages occur more frequently and pose a greater danger.

In view of the substantial savings, it is recommended that the urban core communities should begin preliminary work toward subregional water supply facilities incorporating long-term conservation measures into their plans. Initial steps should lay the legal, fiscal, and administrative groundwork for these facilities, including interconnections between Fargo and West Fargo and between Moorhead and Dilworth. Subsequent work would involve planning for the additional facilities required to serve Fargo and Moorhead jointly, as well as West Fargo and Dilworth.

It is also recommended that studies be conducted to determine the sediment characteristics and exact capacity of the existing in-stream reservoir storage on the Red River. These studies are prerequisites to designing specific water facilities for the urban core communities.

Local, State, and Federal interests must cooperate in developing and implementing an equitable and mutually acceptable water supply plan for the Fargo-Moorhead urban study area.

II. INTRODUCTION

As part of the Fargo-Moorhead Urban Study, the St. Paul District, U.S. Army Corps of Engineers, sponsored a series of water supply/conservation investigations. Phase 1 of these investigations made preliminary demand projections and analyzed low-flow characteristics of area streams. Phase 2 investigated alternative approaches to future water supply for the Fargo-Moorhead area. Phase 3, the subject of this report, evaluates water conservation measures and modifies the water supply plan developed in Phase 2 by incorporating selected measures.

The purpose of this portion of the water supply investigations is to determine the most effective means of water conservation and to evaluate the effects of conservation on the water supply plan and the urban study area. The study initially considers all common methods of water conservation and ultimately screens to a conservation proposal composed of a selected group of the most effective measures. The results of implementing this proposal as part of an integrated water supply/conservation plan are evaluated in terms of economic, environmental, and social impacts on the study area.

The study area is depicted in Figure 1. It includes Harwood, Fargo, Raymond, Mapleton, Reed, Barnes, and Stanley Townships of Cass County, North Dakota; and Kragnes, Oakport, Moorhead, Glyndon, Kurtz, and Elmwood Townships of Clay County, Minnesota. Major population centers are the cities of Fargo, Moorhead, West Fargo, and Dilworth, the study area's "urban core."

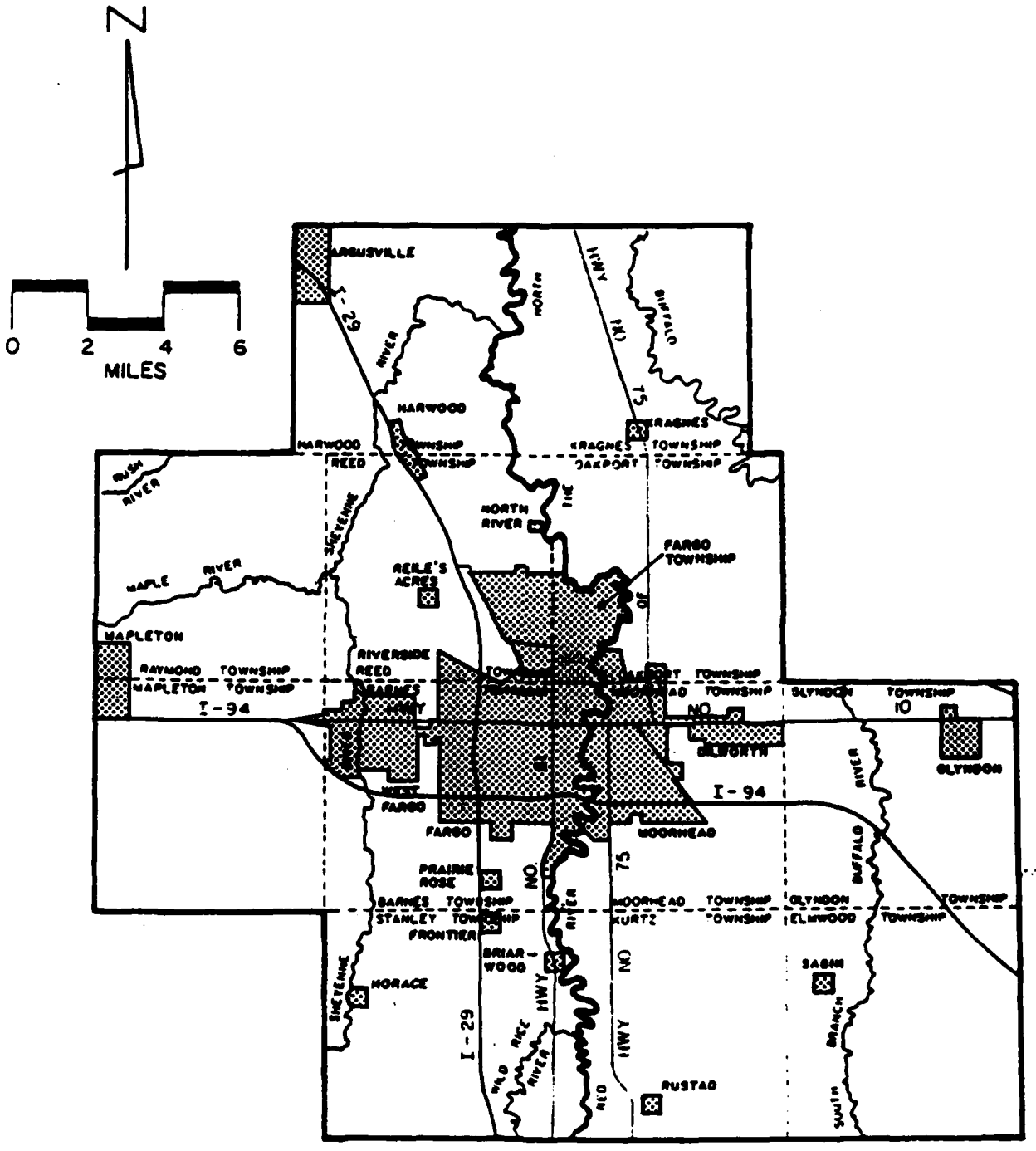


FIGURE 1
Fargo-Moorhead Study Area

The study area is within the Red River of the North basin and includes portions of the Red River, Sheyenne River, Buffalo River, South Branch Buffalo River, Maple River, and Wild Rice River. There are a number of ground-water aquifers in and near the study area.

The plan of development of the report reflects the methodology of the study. Each chapter builds on the previous material. Chapter III introduces possible conservation measures and describes existing conservation efforts. Chapter IV screens these measures to a list of potential measures which are then described in detail in Chapter V. Chapters VI-IX present an evaluation of the effects of individual conservation measures. Based on these evaluations, Chapter X formulates and evaluates the effects of the various proposals (groups of selected conservation measures). Chapter XI develops the drought emergency plans for the selected proposal, and the conclusions and recommendations are presented in Chapter XII.

III. WATER CONSERVATION MEASURES

Possible measures include long-term and contingent measures. Long-term measures would remain in effect throughout the planning period. Contingent measures are crisis-oriented and are implemented only under prescribed circumstances for a limited time. For some measures, it is also pertinent whether they are supply or demand management measures. In these instances, a reference is made in the text. Implementation of supply management measures is often straightforward from the utility management point of view since the delivery system is under its direct control. Demand management measures conserve at the point of consumption by motivating changes in consuming practices. This type of measure is more difficult to implement because it is instituted and enforced with governmental authority and requires municipal support.

1. Metering

Metering is a long-term measure involving the installation of water meters on all municipal service connections. The meters record the exact amount consumed and directly link the consumers' costs to their consumption. This concept is vital to many forms of conservation, and it is also a measure in itself. Metering has been repeatedly shown to reduce consumption; however, a portion of this effectiveness is directly related to the pricing method that is implicit in this measure.

2. Meter Maintenance

Meter maintenance is a long-term, as well as a supply management measure. A high percentage of residential meters tend to mis-register low flows after approximately 10 years of service. Industrial and commercial meters must be calibrated more frequently since they measure larger volumes of water, and a small percentage of error can amount to a significant volume of water. The

meter maintenance measure includes an organized program of meter calibration, maintenance, and replacement. The implementation of this measure facilitates a more accurate accounting of water use and ensures that those consumers with mis-registering meters pay for the full amount of water they use. Meter maintenance increases the water bills of affected consumers, and they respond by reducing their consumption.

3. Pressure Regulation

Pressure regulation is a long-term measure. It conserves water by installing pressure-reducing valves that reduce pressures below 60 pounds per square inch (psi) in residential and light commercial service connections. Reduced pressures conserve water by subsequently lowering leakage rates and wasteful domestic water use.

4. Leak Detection

Leak detection is a long-term as well as a supply management measure. It represents a program that includes leak detection, repair, and rehabilitation. This measure is most effective where high percentages of unaccounted-for water indicate a large amount of system leakage.

5. Pricing

Pricing is a long-term measure that includes various conservation-oriented pricing methods. These methods are divided into average demand pricing structures, peak demand pricing structures, and other pricing measures. Pricing gives the consumer motivation to reduce consumption. A price increase for a particular quantity or time of year may cause the user to inventory his uses. Subsequently, the user may eliminate or reduce those uses that he values less than the cost of the water required to maintain the use. Average demand

structures are considered primarily effective in reducing average annual demands, and peak demand structures are considered primarily effective in reducing peak demands.

Though a community may have already adopted an appropriate conservation-oriented pricing structure, some measures may still be compatible and offer additional reductions.

6. Economic Incentives

Economic incentives are long-term measures that motivate conservation actions with monetary incentives or penalties. Economic penalties are considered the same as penalty charges, the contingent pricing measure.

Monetary incentives include rebates, tax credits, and subsidies. The conservation response to these rewards is greatly dependent upon the size of the incentive relative to the costs of the action. This study considers the use of economic incentives to install water-saving fixtures in new construction.

7. Water-Saving Devices

Water-saving devices are long-term measures. The use of water-saving devices in place of regular fixtures conserves water. Four variations of this measure are possible: fixtures for new construction, retrofit devices distributed as kits, retrofit devices distributed and installed, and water-saving devices for landscape irrigation.

Water-saving fixtures can be installed in new construction using local plumbing codes or economic incentives. In either case, water-saving criteria would be established and devices which met the specifications would qualify. Common water-saving fixtures include various types of low-flow toilets and showerheads, aerating faucets, and low water-using clothes washers and dish washers.

Retrofit devices include simple devices that fit into existing water fixtures and reduce water flow. Common devices include toilet water dams, faucet aerators, flow-reducing inserts for showers, and flow-reducing buttons for faucets. Dye tablets for leak detection may also be included. Retrofit devices can be distributed and installed by municipal and utility personnel or distributed as retrofit kits with hopes that the consumer will perform the installation.

Devices for landscape irrigation conserve water by helping the consumer to determine when irrigation is necessary and to regulate the amount of water that is applied. These devices can include hose meters, sprinkler timers, and moisture sensors.

8. Industrial Process Modifications

Industrial process modifications are considered a long-term measure that can conserve by recycling and re-using water that is normally discharged. To adequately address this measure, detailed information about water use in specific processes is required from individual industries. Available information about the major industrial water users is included in this report.

9. Re-Use of Municipal Wastewater Effluent

Re-use of municipal wastewater effluent is a long-term measure. Municipal wastewater effluent may be re-used for potable and non-potable use. However, potable water re-use on a municipal scale is not practiced in the United States (AWWA, 1983). Water is suitable for non-potable use after secondary treatment and disinfection or if it has adequate detention time in a stabilization pond. Non-potable re-use has been adopted where the re-use facilities can be strictly managed. Medical concerns require that careful controls be used to prevent contamination and infection. This measure conserves water by substituting recycled water for municipally-treated irrigation water in suitable areas.

10. Re-Use of Municipal Process Water

Re-use of municipal process water is a long-term measure. Municipal process water includes water used to backwash filters and clean water treatment facilities. In some water treatment plants, this water is discharged and lost. In these cases, water can be conserved by clarifying the process water and then returning this water to the head of the plant. The only two existing or presently planned water treatment plants in the study area are in Fargo and Moorhead, and both these plants presently recycle their process water.

11. Federal and State Regulations

Federal and State regulations are long-term measures that are implemented using regulations adopted at different levels of government. Regulations subject to amendment only at Federal and State levels are essentially beyond local control and, hence, not addressed in this study. Local regulations and any Federal or State laws subject to amendment at the local level are discussed in the measure, Local Codes and Ordinances.

12. Local Codes and Ordinances

Local codes and ordinances include long-term and contingent measures. These measures can be used as measures in themselves or as a means of implementing other conservation measures. In the first case, an ordinance may be passed regulating lawn sprinkling. This measure would directly conserve water by mandating changes in consuming practices. In the second case, plumbing codes can be used to implement a conservation measure requiring the installation of water-saving devices that, in turn, conserve water. Restrictions rationing water or establishing bans on water use are examples of contingent measures.

13. Restrictions Rationing Use

A restriction rationing use could conserve water by limiting consumption to a certain allotment. This conservation measure is considered as an appropriate measure during severe water shortages.

Many different indices may be used to arrive at these allotments. This study examines fixed allocation, utilizing a set standard upper limit of use per household; per capita use allocation based on occupancy; and variable percentage allocation, where allotments may vary according to some related index like irrigable acreage. Usually, the target of rationing is residential irrigation.

14. Restrictions Determining Priority Use

Restrictions determining priority use are considered contingent measures. These restrictions conserve water by forbidding certain water uses. Commonly, outdoor uses such as irrigation and car washing are banned.

15. Education Measures

There are many different educational measures. These measures are vital to the successful implementation of most long-term or contingent conservation measures. However, they may also be used as measures in themselves. In the latter case, direct mail brochures or billing inserts may be used to point out wasteful practices and encourage a change in lifestyle that conserves water and reduces consumers' bills.

B. CURRENT AND PLANNED WATER CONSERVATION MEASURES

This section describes current water conservation efforts being made by urban core and rural communities within the study area. Measures which have been previously implemented or for which definite commitments to implement have been made are discussed. Information for this section has been obtained from Federal, State, and local sources.

In general, current conservation actions are not organized programs or specifically outlined measures per se. Rather, these actions represent limited efforts taken to address certain problems as they arise. Communities are already experiencing some implicit reductions as a result of these efforts; however, accurate estimates of effectiveness are not possible. The current data from the utilities used to develop demand projections implicitly reflect these reductions. The existing water demands, including implemented conservation measures, provide a baseline to which additional conservation measures may be applied. Current and planned water conservation measures will be eliminated from the list of applicable measures evaluated for further water conservation. In the following discussion, current efforts are discussed according to the specific conservation measures they most closely represent.

1. Metering

Metering provides a community with the means of charging customers for the exact quantity they use. Metering produces reductions in water use and is the basis for a variety of other conservation measures. Currently, all study area communities are fully metered except the rural communities of Glyndon and Sabin and those communities where homeowners are served by their own individual systems (Reile's Acres, Prairie Rose, Rustad, and Kragnes).

2. Meter Maintenance

A high percentage of meters tend to mis-register low flows after 8 to 10 years of service. An organized program of meter maintenance prevents losses due to mis-registration and ensures that utilities receive revenue for the actual amount of water they provide. The metered communities currently replace broken meters when they are identified in the meter reading process. However, no

community reports an organized program of calibration and repair or replacement. Moorhead is replacing broken meters with magnetic meters. This practice has conservation value because magnetic meters are more accurate and require less maintenance (New England River Basin Commission, 1980 b).

3. Leak Detection and System Maintenance

Though no study area community has a leak detection program per se, all communities with municipal and Cass Rural Water Users Association (CRWUA) bulk systems monitor master meters, customer meters, and/or sewer return flows to identify abnormal losses and locate the larger leaks. Water utility managers feel that these monitoring efforts have been sufficiently successful, particularly in rural communities. It is difficult to evaluate the feasibility and effectiveness of the more advanced leak detection programs. However, they are typically unjustified unless unaccounted-for water is 15 to 30 percent of the total water supply (AWWA, 1984). Fargo is the only community in the study area known to have an unaccounted-for water use in this range.

4. Pricing

Several conservation-oriented pricing measures are currently implemented in the study area. These measures include declining block and uniform unit pricing structures, demand charges, and other surcharges. Both the rate structure and the associated price levels (price per unit consumed) affect water consumption. All pricing systems are designed to recover the total cost of service. Conservation-oriented pricing systems also attempt to effectively encourage reductions in water use.

Declining block pricing is the most common rate structure in the study area and in the United States as a whole. Under this rate structure, the price per unit of water decreases in a stepwise manner with the quantity consumed. Large water

users favor this rate structure for obvious reasons. This type of structure is justified when water utilities are realizing economies of scale; the cost per unit of water supplied decreases with increasing quantities produced. This is probably true when there is sufficient supply. Declining block pricing has been reported to be capable of reducing peak and/or average water use (New England River Basin Commission, 1980a). Communities which have adopted this pricing structure are experiencing some water use reductions. The amount is site-specific and varies according to price levels, elasticity of demand, and mix of consumers.

Uniform unit or single block pricing is used by Dilworth and Briarwood. Under this rate structure, the price per unit of water is constant, regardless of the quantity consumed. Therefore, the cost to the consumer will increase in direct proportion to the amount of water consumed. This type of structure may be appropriate when the cost of production is the same for the first and last units produced. Because total cost is directly proportional to the quantity consumed, there is an incentive to conserve. Communities which have adopted this structure are experiencing some water use reductions. Though a conservation-oriented pricing structure such as declining block or uniform unit pricing may have already been adopted, other pricing measures may be compatible and offer additional reductions. These measures are discussed as potential conservation measures in Chapter V.

A demand charge is a flat charge for the first quantity of water consumed. It includes costs associated with the extra connections, capacity, and maintenance required to adequately supply the numerous relatively low volume users. In addition to the cost for the quantity of water, this charge offers a slight conservation effect because it raises the price level of the initial

quantity. Other special use charges are also used. Fargo discourages excessive use by adding a surcharge for "nonconserving" air conditioning equipment. This surcharge has reportedly eliminated this type of equipment.

5. Water-Saving Devices

North Dakota State University (NDSU) is one of the area's largest commercial water users. In 1975, NDSU began a three-phase energy conservation program. Each stage called for an increasing capital investment. As part of Stage 2, a number of water-saving devices were installed: low-flow showerheads were installed in dorms and the two field houses, and continuous-flush urinals were replaced. Based on 10 years of average annual sewage flows, domestic use was reduced approximately 13 percent. This was largely a result of these measures.

Other water conservation measures were also taken to reduce energy costs. Piping is checked for proper insulation and leaks on a continual basis. Hot water tank coils are cleaned annually. Mixing valves for boilers and water-using appliances are adjusted to conserve hot water. As a preventive measure, all future building plans are reviewed to identify potential conditions that waste energy. Outside, lawn and shrub watering is kept to a minimum, and automatic sprinklers are put on timers and monitored. These modifications produced reductions similar to those just reported.

To effectively implement these measures, NDSU has used a number of common educational measures. The students, staff, and faculty have been contacted through the campus newspaper, bulletins, and intra-campus memorandums. These publications have kept the campus continually informed of the needs for conservation and of the progress being made.

6. Industrial Process Modifications

The two major industrial water users in the study area are the American Crystal Sugar factory and the Anheuser-Busch malting plant in Moorhead. Both of these industries have already taken steps to conserve water.

The American Crystal Sugar factory uses between 0.3 mgd and 0.5 mgd of municipally-treated water on an average annual basis. This water is initially used for boiler feed and an ion exchange process. It then may be recycled through various portions of the plant. The factory is presently conducting a re-use/recycle study, with a goal of reducing municipal water use up to 50 percent. To achieve this goal, it is hoped that condensate from other plant processes may be substituted for municipally-treated water.

The Moorhead facility of Busch Agricultural Resources, Inc. was constructed in 1979. As such, it is one of the more modern production facilities of its type. The design of the plant incorporated some of the most energy and water efficient processes and equipment available to the industry.

The malt plant uses between 0.75 and 0.84 mgd of municipally-treated water on an average annual basis. Municipally-treated water is used primarily in steeping or soaking the grain prior to germination. Water is also used for germination, cooling tower makeup, cleanup, boiler feed, and domestic/sanitary purposes.

7. Re-Use of Municipal Process Water

Fargo and Moorhead have the only water treatment plants in the study area. Both plants are designed to re-use process water. The Fargo plant recycles its filter backwash water by removing the solids and returning the water for further treatment. The solids are then thickened and landfilled along with the sludge.

The Moorhead water treatment plant discharges its filter backwash and settling tank draw-off water to settling ponds where the suspended solids are separated through sedimentation.

These ponds also receive stormwater runoff from a limited area. Clarified water is then returned to the head of the treatment plant. Periodically, the sediment will be dredged from the ponds and disposed of properly.

8. Federal and State Regulations

Federal agency programs related to water conservation are shown in Table 1. Federal involvement with water conservation in Minnesota and North Dakota is primarily limited to planning, technical assistance, and/or funding.

State programs affecting water conservation are summarized in Table 2. State regulations that can be considered regulatory conservation measures are discussed in this section.

A major difference in water law exists between North Dakota and Minnesota, though both States control water development with permits. North Dakota water law considers that priority in time establishes a priority of right. In Minnesota, water appropriation rights are allocated based on a priority system and a criteria of reasonable use. These priorities are outlined as follows:

First priority. Domestic water supply, excluding industrial and commercial use of municipal water supply.

Second priority. Any use of water that involves consumption of less than 10,000 gallons of water per day. "Consumption" means water withdrawn from a supply which is lost for immediate further use in the area.

TABLE 1

FEDERAL AGENCY PROGRAMS RELATED TO WATER CONSERVATION

Department	Agency
Agriculture	Agricultural Stabilization and Conservation Service
	- Agricultural Conservation Program - Water Bank Program
	Farmers Home Administration
	- Business and Industrial Loans - Irrigation and Drainage and Other Soil and Water Conservation Loans - Farm Ownership Loans - Resource Conservation and Development Loans - Soil and Water Loans - Water and Waste Disposal Systems for Rural Communities
	Soil Conservation Service
	- Conservation Operations -- Technical Assistance - Resources Conservation and Development - Rural Clean Water Act - Soil and Water Conservation Program
	Forest Service
Army	Corps of Engineers

	- Comprehensive Studies
	- Civil Works Research and Development
	- Coordination with Other Federal Agencies and Non-Federal Interests
	  - Comprehensive Planning Cooperation
	  - Wastewater Management Program
	  - River Basin Commissions
	- Project Planning, Level C Implementation Studies
	- Regulatory Functions to Protect/Preserve Navigable Waters and the Environment

Commerce	Economic Development Administration
	- Industrial Development Loans, including loans for construction of related public works - Technical Planning and Research Assistance - Funds Multi-County Planning Offices

TABLE 1 (continued)

FEDERAL AGENCY PROGRAMS RELATED TO WATER CONSERVATION

Department	Agency
Commerce (continued)	National Bureau of Standards
	- Plumbing Systems Program - Sewerless Devices Evaluation Basis - Water Conserving Devices
	National Oceanographic and Atmospheric Administration
	- National Weather Service
	Small Business Administration
	- Local Development Company Loans/Regular Business Loans
Energy	Conservation and Solar Applications
	- Energy Conservation
Environmental Protection Agency	Office of Regional and Intergovernmental Operations
	- Interstate Cooperation and Uniform Laws
	Office of Water and Waste Management
	- Clean Lakes Program - Construction Grant for Wastewater Treatment Works - Sections 104, 105(d)(2), 105(e)(1), and 214 of the Clean Water Act of 1977, P.L. 95-217 - State- and Area-Wide Waste Treatment Management - State Pollution Control Program
	Office of Environmental Education
	- Environmental Education Program
	Office of Community Planning and Development
	Office of Housing
	New Communities Administration
	Federal Disaster Assistance Administration

TABLE 1 (continued)

FEDERAL AGENCY PROGRAMS RELATED TO WATER CONSERVATION

Department	Agency
Housing and Urban Development	Funds for Community Planning and Development of Water Facilities
	- Community Development Block Grants - Small Cities Block Grants - 701 Planning Assistance
Interior	Bureau of Land Management
	- Cooperative River Basin Studies - Soil-Air-Water; Soil Inventory
	Bureau of Reclamation
	- Loan Program
	Fish and Wildlife Service
	- Environmental Assessment of Planned Developments
	Water and Power Resources Service
	- Planning Program for Study and Development concerning Conservation of Water for Hydropower, Recreation, and Fish and Wildlife Development
	- Loans for Irrigation Projects
	- Planning Studies
	Geological Survey
	- Water Resources Division - Data on Surface and Groundwater - Funds Local Hydrologic Investigations

TABLE 2

MAJOR STATE WATER CONSERVATION PROGRAMS

Minnesota Department of Health

- Authority to develop emergency water supply plans.
- Authority over well drillers.
- Reviews public water facility plans and administers Federal grants for construction of water facilities.
- Promulgates standards for plumbing installations.

Minnesota Department of Natural Resources

- Permitting authority for appropriatioin of ground and surface water. Permit includes submission of a contingency plan if appropriation should be restricted.
- Authority to develop State water conservation program.
- Enforce priority allocation program during water shortages. There are five priorities: 1) domestic water supply, excluding commercial and industrial uses of water supply, which includes agricultural irrigation using more than 10,000 gallons per day; 2) any use of water less than 10,000 gallons per day, "use" meaning water consumed and lost from immediate future use; 3) power production consuming over 10,000 gallons per day; 4) industrial and commercial uses requiring over 10,000 gallons per day; 5) other uses requiring over 10,000 gallons per day. Under this priority system, if a lower-priority user interferes with the water supply of a higher-priority user, the higher-priority user has legal precedence over the resource.

North Dakota Natural Resource Council

- Coordinate and develop long-range plan for use and management of State's water resources.
- Initiate investigations.
- Review and evaluate the programs of State agencies that concern interdepartmental management, planning, or regulation of the State's natural resources.

TABLE 2 (Continued)

North Dakota State Water Commission

- The Commission and the State Engineer have jurisdiction over all water resource projects in the State, including authority to:

  Regulate water flow to minimize flood damage and stream pollution.

  Impound water for municipal, industrial, and rural water supplies.

  Improve stream channels.

  Construct and maintain dams, reservoirs, diversion canals, and drainage channels.

  Investigate and plan further projects.

- Authority to establish rules and regulations for sale of water and water rights, control of water supplies, control of water pollution, financing of water development projects, and issuing drainage and dike permits.

Third priority. Agricultural irrigation and processing of agricultural products involving consumption in excess of 10,000 gallons per day, and processing of agricultural products.

Fourth priority. Power production involving consumption in excess of 10,000 gallons per day.

Fifth priority. Other uses involving consumption in excess of 10,000 gallons per day.

The rules of appropriation in Minnesota safeguard the domestic needs of municipal water supplies, whereas in North Dakota, a community could be required to purchase additional rights to ensure that similar needs were met.

State statutes grant communities the power to make restrictive ordinances limiting municipal water use. Minnesota State Statute 105.418 requires public water suppliers to adopt and enforce regulations restricting use during periods of critical water shortages. North Dakota State Statutes implicitly allow the adoption of regulations restricting water use, as well as allowing modifications of the building code at the local level (Rosell Sand, 1984). Minnesota communities cannot implement local building codes more restrictive than the State code.

9. Local Codes and Ordinances

Sprinkling ordinances are used by area communities to conserve water during severe shortages. Sprinkling ordinances were invoked in Fargo and Dilworth during August of the 1976 drought (for the entire month and the last two weeks, respectively). Residential demands were reportedly decreased. It is not possible to accurately quantify these reductions due to the limited availability of local data; however, the Fargo Water Superintendent's office estimates as much as a 30-percent reduction in residential use may have been achieved.

Dilworth can use restrictions that prioritize use to conserve water. The city has recently adopted an ordinance that can ban non-essential water uses like car washing and lawn irrigation during water shortages. However, to date this measure has not been implemented. Moorhead has also used restrictions to ban non-conserving air conditioning systems.

IV. IDENTIFICATION OF POTENTIAL WATER CONSERVATION MEASURES

A. GENERAL

Potential water conservation measures are selected from possible measures by applying three criteria -- applicability, technical feasibility, and social acceptability. This section describes how each measure was evaluated for each criterion. Any measure which at least "potentially" qualified for all three criteria is retained as a potential measure.

Possible conservation measures are examined for their suitability in both urban core and rural communities because a separate conservation plan will eventually be developed for each group of communities. Different conservation measures may be appropriate for the two different groups of communities primarily because of the smaller scale of the rural municipal systems and their preponderance of residential consumers.

Following a brief explanation of the three criteria, the evaluation of each possible measure will be presented. The results of the identification process are summarized in Tables 4 and 5 near the end of this chapter.

1. Applicability

The first criterion is applicability. Possible measures are applicable if they meet the following tests:

1. They address water uses which occur or are expected to occur in the study area communities.

2. They have not already been fully implemented in the study area communities.

3. No definite commitments for future implementation in the study area communities have been made.

2. Technical Feasibility

The second criterion is technical feasibility. Possible measures are technically feasible if, when implemented, they can produce measurable reductions in the quantity of water used. Only one measure was eliminated because it was not technically feasible. However, several measures were classified as "potentially" feasible. The conditions surrounding this determination are described in this section. The same measures were determined to be potentially technically feasible for urban core and rural communities.

3. Social Acceptability

The third criterion, social acceptability, is the most difficult to define. The social acceptability of a measure is a judgment of whether or not the measure is in line with the social ideology of the area. The goal of this criterion is to gain knowledge about community values, attitudes, and feelings which might influence receptivity to aspects of water conservation; then, to apply this knowledge to determine impediments to implementation and make a judgment about the social acceptability of specific measures. Any judgments of social acceptability are subjective in nature.

Major social ideologies can be identified. During the course of this study, there have been many opportunities for local interaction with area businesses and industries, water utilities, and government officials of area communities. The Fargo-Moorhead Metropolitan Council of Governments (MCOG) has provided local coordination for this study through its Water Resources Committee. This committee has members from many groups influential in water-related decisions -- water utilities, government, engineering firms, area colleges, and the MCOG staff.

The latter offers knowledge of local special interest groups such as Chambers of Commerce, municipal and industrial development groups, and homeowners.

The U.S. Army Corps of Engineers has conducted a social acceptability survey of the Fargo-Moorhead study area. The findings in this study are based upon responses from a random, biased sample of the population of the 17 communities of the Fargo-Moorhead urban study area. The sample is biased because it was taken from the Fargo-Moorhead telephone director (1982 edition) and thus included only those individuals and businesses listed in the directory.

This survey mailed a questionnaire addressing specific aspects of common types of water conservation measures. A copy of the questionnaire is included in Appendix C. The questionnaire evaluated five dimensions of public attitude on seven general water conservation measures. These five dimensions are:

1. How much does the respondent know about the particular measure?
2. How well does the respondent think it will work?
3. How economical does the respondent think it would be?
4. How serious would the need for conservation have to be before the respondent would adopt it?
5. Overall, how does the respondent evaluate the measure?

Table 3 summarizes the attitudes of area residents towards common water conservation measures. The results of the questionnaire have been classified as opposed, ambivalent, or favoring, based on important factors affecting implementation. These factors include consumers' perceptions about cost savings, effectiveness, and general knowledge of the measure.

TABLE 3

ATTITUDES TOWARD COMMON WATER CONSERVATION MEASURES

	% of Respondents			Important Factors
	Opposed	Ambivalent	Favoring	That Can Be Affected
Installation of water-conserving plumbing fixtures	33	28	39	Cost savings
Education campaigns about water conservation	25	31	44	--
Re-use of municipal wastewater	26	23	51	Effectiveness/cost savings/knowledge*
Building codes requiring water-saving fixtures in new construction	11	18	71	Effectiveness
Pricing structures increase cost per unit as consumption increases	49	23	28	Effectiveness/ knowledge*
Lawn sprinkling water reduced by 50 percent	43	28	29	Cost savings
Fines as penalties for violation of conservation regulation	54	25	21	--

*A relationship exists in that the more people feel they know about the measure, the less they approve of it.

When statistical analysis reveals that significant relationships exist between certain factors and attitudes, the pertinent factors are shown in the final column. For example, the public's perceptions of cost savings significantly affect their attitude towards the installation of water-conserving fixtures.

These factors and other social acceptability data are utilized to determine social acceptability for specific measures. This material is also an important consideration in designing implementation plans.

B. ANALYSIS OF INDIVIDUAL MEASURES

The following section describes the evaluation of individual measures. Potentially socially acceptable measures are retained as contingent measures and are included in Chapter V.

1. Metering

Metering is not applicable in the urban core communities because they are already completely metered. However, since Glyndon and Sabin are not yet metered, this measure remains applicable for the rural communities. In these communities, metering is also technically feasible and socially acceptable. Therefore, metering has been retained as a potential measure for the rural communities.

2. Meter Maintenance

Meter maintenance meets all three criteria in urban core and rural communities. This measure has been retained as a potential measure for both groups of communities.

3. Pressure Regulation

Pressure regulation is not applicable in urban or rural communities. The purpose of this supply management measure is to reduce pressures below 60 psi in residential or light commercial portions of the urban municipal service area (Flack, 1977). Pressures of 60 to 80 psi cause excessive leakage and

wasteful domestic water use. These pressures can occur where there are significant variations in topography, in residential-light commercial areas immediately adjacent to heavy industrial water users, or near booster pumping stations (AWWA, 1981). The utility would implement the measure by installing pressure-reducing valves in affected mains or service connections. Conditions in the study area make this measure not applicable. Currently, the normal operating pressures in water distribution lines are significantly below pressures that cause excessive leakage. In addition, the topography of the study area is generally quite flat, and the larger industrial water users tend to be isolated in industrial parks. Therefore, pressure regulation is not considered a potential conservation measure.

4. Leak Detection and System Maintenance

Leak detection, repair, and rehabilitation is applicable for the urban core communities but not for the rural communities. It is generally only feasible for communities with 15 to 30 percent unaccounted-for water (AWWA, 1981). Small communities generally require unaccounted-for water in the upper end of this range to justify a system-wide leak detection and rehabilitation program. Unaccounted-for water is not estimated to be this large in the rural communities because the larger leaks can be readily identified using current methods of monitoring return flows and meter readings. The relatively small distribution systems and small volumes of water consumed by these communities facilitate this method. Thus, leak detection and system rehabilitation is deemed not applicable for the rural communities. However, it is applicable for urban core communities where percentages of unaccounted-for water are in the range specified above and where identification of leaks requires a systematic program.

Leak detection is also technically feasible and socially acceptable for the urban core. Therefore, it has been retained as a potential measure for the urban core communities.

5. Pricing

If a community has already adopted an appropriate conservation-oriented pricing structure, other pricing measures that are not compatible with the existing structures are no longer applicable. Demand charges and uniform unit or declining block pricing measures have been appropriately adopted by all study area communities except Glyndon and Sabin (see Chapter III). With the exception of these communities, these measures and other non-compatible measures are no longer applicable. On this basis, the following measures remain as candidates for potential measures (except for Glyndon and Sabin): peak daily load, seasonal surcharge, excess use charge, and hook-up fees. Since Glyndon and Sabin have yet to meter and hence adopt a conservation-oriented pricing structure, all pricing measures are applicable there. Though as indicated previously, once a structure is adopted, certain other measures are no longer applicable and become ineligible as candidates for potential measures.

All pricing measures meet the criterion of technically feasible, though no reductions directly attributable to hook-up fees have been reported.

The U.S. Army Corps of Engineer's social acceptability study shows that pricing measures may be opposed by a significant portion of the population. Commonly, this opposition stems from the increased costs that may be associated with the measure although other causes of social opposition are also possible.

A hook-up fee is considered socially unacceptable in urban core and rural communities. Hook-up fees conserve water directly by reducing the number of new connections, hence this control operates implicitly by limiting community

growth. In the population projection process, communities stated that they believed continued growth was directly associated with their future health. Because ordinances that restrict growth would be against this social ideology, application of hook-up fees was determined to be socially unacceptable.

It is also possible to use reduced hook-up fees as a vehicle to encourage the installation of water-saving fixtures in new construction. In this application, a reduction in the hook-up fee or a rebate would be a subsidy, a form of economic incentive. Economic incentives are retained as potential water conservation measures.

6. Economic Incentives

All variations of the economic incentive conservation measure are retained as potential water conservation measures for urban core and rural communities. This measure is discussed in detail in Chapter V.

7. Water-Saving Devices

Water-saving fixtures for new construction, free distribution of retrofit conservation kits, and free distribution and installation of retrofit devices are variations of the water-saving device measure and are retained as potential measures for urban core and rural communities. However, devices for residential irrigation are of questionable social acceptability and are only potentially technically feasible because no measurable reductions in water use have been reported as a result of their use (Stone, 1980). Less costly educational alternatives are available.

Moisture sensors are used for parks and recreational areas but are not economical for residential sprinkling applications. It is doubtful that their application would become common enough to affect a reduction in maximum day demands (Stone, 1980). Hose meters or sprinkler timers might be capable of reducing maximum day demands if their use were encouraged or mandated. They

could reduce overwatering, since in most cases, residential irrigation is unmetered and untimed. Sprinkler timers can be extremely expensive and a widespread economic incentive of this size for an unproven reduction does not seem socially acceptable. Therefore, sprinkler timers are not socially acceptable.

A field test of hose meters could be conducted to determine their effectiveness in the study area. If they were determined effective, they could be offered along with other water-saving devices at distribution depots.

8. Industrial Process Modifications

Industrial process modifications are a potential conservation measure for the urban core communities. One rural community, Riverside, has a relatively large industrial water user, but it is essentially self-served.

Industrial process modifications are considered potentially technically feasible. It is difficult to estimate reductions in water use that may be achieved through industrial process modifications. Industries carefully guard data about water used in specific industrial processes. Analyses of this type are studies in themselves for industrial engineers familiar with the specific industry. However, the larger industrial water users of the area have provided useful information, and this material is summarized in Chapter V.

9. Re-Use of Municipal Wastewater Effluent

Re-use of municipal wastewater effluent, including both potable and non-potable uses, has been determined not applicable for urban and rural communities. Currently, potable water re-use on a municipal scale is not practiced anywhere in the United States (AWWA, 1983). Social and medical concerns about establishing acceptable tests and controls for viruses, pathogens, and toxins

have limited its applications in this country. Water re-use for non-potable uses has been adopted where the re-use facilities can be strictly controlled by the purveyor. Such control is required to prevent crossconnection with any part of the potable water distribution system. Water re-use has been proven feasible for irrigation and other uses that do not require the construction of an extensive dual system (a system with two separate distribution systems for potable and non-potable water). Irrigation of green belts, some agricultural crops, and other areas in the immediate vicinity of the sewage treatment facilities are examples of proven feasible uses. Regulating agencies are often reluctant to approve irrigation of parks and golf courses for fear of viral infection.

Re-use of wastewater effluent in Fargo and Moorhead could supply water for the irrigation of suitable areas nearby wastewater treatment plants in each city; however, these areas are now almost entirely self-served. Therefore, this measure would not be technically feasible because no reductions in municipal water demand would result. Also, the Red River depends heavily on wastewater effluent (return flow) for sustaining aquatic life and other downstream uses. In severe droughts, natural streamflows can fall as low as 1 cfs and frequently fall below desirable minimum in-stream flow requirements -- for example, 7 cfs according to the Souris-Red-Rainy River Basins Comprehensive Study. Return flows on the order of 30 cfs become a major component of streamflows. Eliminating the return flow could cause severe, socially unacceptable environmental consequences for aquatic life.

For these reasons, wastewater re-use is not an alternative in the urban core communities. Water re-use in the smaller rural communities is also not technically feasible or socially acceptable for similar reasons. Stabilization

pond effluent may be usable for field irrigation in isolated instances; however, since this irrigation is presently self-served or undeveloped, such re-use will not reduce future rural demands if the present situation continues.

10. Re-Use of Municipal Process Water

Re-use of municipal process water is not applicable in either urban core or rural communities. The only existing or planned water treatment plants are in Fargo and Moorhead, and both of these plants presently recycle their process water.

11. Federal and State Regulations

Federal and State regulations can be placed in three groups for the purpose of analyzing applicability. These groupings include already implemented regulations, regulations amendable only at Federal and State levels, and those regulations which are amendable at the local level. The first two groupings are not applicable in the study area. Already implemented measures are not applicable because they are presently in force, and regulations amendable only at the State and Federal levels are not applicable because changes at these levels are essentially beyond local control. Since the last grouping of regulations can be implemented only through changes in local ordinances, these regulations are addressed in this report as local codes and ordinances.

12. Local Codes and Ordinances

Plumbing codes and sprinkling ordinances are retained as potential measures for all study area communities. Changes in landscape design were not applicable, and residential water recycling and retrofitting ordinances were not socially acceptable. Therefore, these measures were not considered as potential water conservation measures.

Changes in landscape design would conserve water primarily by reducing residential irrigation. Landscape changes include the use of native low-water using plants and limits on lawn size and slope. Only limited types of native plantings have been identified and tested in the study area to date and limits in lawn slope are not appropriate due to the low relief of the area.

Water reductions as a result of the implementation of this type of measure would be highly variable, site-specific, and depend heavily upon the degree of change which is mandated. Even if a local model test area was available, it would be difficult to estimate the effects of total implementation. For these reasons, this measure has been classified as only potentially technically feasible.

In addition, changes in landscape design are socially unacceptable. A vital component of the social acceptability of changes in landscape design is aesthetic appeal. The study area is located in one of the Nation's most productive agricultural areas and the local social ideologies of the area strongly reflect this influence. Green lawns, parks, and all types of gardens are a source of community identity and pride. Fargo has had a "lawn of the week" program and area businesses often offer special garden areas to attract customers.

Plants native to the area include typical long grass prairie vegetation. Native grasses do not have a similar appearance to bluegrass. Commonly, native grass stands are less dense and have a dried or bleached appearance. The overall effect is a significant change from the aesthetic appearance of the surrounding verdant agricultural region. In addition, mandating changes in local lawn size is likely to be viewed as unreasonable.

To ensure public support, any sacrifices required by the individual residents should be preceded by public actions. This means the park system would be required to reduce water use and the extent of public flower gardens and other plantings.

The parks of the area are heavily used for aesthetic and recreational purposes. Any significant change in the aesthetic appearance of the parks would have a large negative public impact. Trollwood Park in Fargo is a very popular area park, and the public flower gardens in the downtown areas are a fixture. Interviews with knowledgeable local water authorities also indicate that changes in landscape design would not be well accepted. They felt that there would be no politicial support for such an ordinance or code.

For these reasons, this measure was deemed to be socially unacceptable. However, aspects of water-efficient landscaping and residential irrigation would definitely be included in any general water conservation education program.

Ordinances requiring residential water recycling are not applicable in the study area. Residential re-use/recycle systems are relatively expensive, require extensive maintenance, and can be difficult to operate properly. These systems become cost-effective only in remote areas where water supply and disposal costs are prohibitive (New England River Basins Commission, 1980). Commercial and industrial re-use/recycle systems have already been implemented by major water-using firms. The adaptations made by these users are discussed along with other previously implemented conservation measures.

Local retrofitting ordinances are considered socially unacceptable even under contingent conditions. The measure would conserve water by requiring all homes to install low-flow shower heads, faucet aerators, toilet dams, and other

water-saving devices. These devices have use characteristics similar to regular fixtures; however, differences in operating characteristics may be noticeable. Since these devices affect personal use habits, a regulation requiring their installation may often be seen as an unwarranted invasion of privacy. These devices are easily removed and the ordinance is virtually impossible to enforce. Therefore, cooperation of the consumer is paramount. Measures calling for voluntary retrofitting or use of codes for installing fixtures in new construction should be relatively well accepted and present an effective vehicle for implementing a retrofit program. For these reasons, retrofitting ordinances are not included as a potential measure.

13. Restrictions Rationing Use

Restrictions that utilized fixed allocation, per capita use, or a variable percentage to ration use were retained as contingent conservation measures for the study area. Restrictions rationing use on a prior-use basis were classified as socially unacceptable and were not retained. The latter type of restriction would ration use during times of severe drought based on prior use during a defined period. Local authorities felt that rationing on this basis was inequitable since those who were already conserving could suffer by receiving an unfair allotment.

14. Restrictions Determining Priority Use

Restrictions determining priority use were retained as contingent conservation measures for all study area communities. This measure is discussed in detail in Chapter V.

15. Education

Educational measures meet all three criteria for both groups of communities. Therefore, this measure has also been retained as a potential measure. This measure is discussed in detail in Chapter V.

C. SUMMARY OF IDENTIFICATION ANALYSES

Tables 4 and 5 summarize the identification of potential water conservation measures for the urban and rural communities, respectively. Potential measures must be applicable, technically feasible, and socially acceptable. Any measure which could at least "potentially" meet these criteria is retained as a potential measure. These measures are underlined in the tables and are carried throughout the remainder of the report as potential long-term water conservation measures. Long-term measures are implemented once and remain in effect for the remainder of the planning period. Even though in effect continuously, they may be intermittent in actual application, such as restrictions on seasonal sprinkling uses. Contingent measures differ from long-term measures in that they are limited to a particular time span, are usually crisis-oriented, are rapidly mobilized, and are employed only under prespecified circumstances. The contingent measures may be similar to any of the long-term measures but may be applied for a shorter duration and with greater emphasis, depending on the local situations. Therefore, certain contingent measures such as rationing during periods of droughts differ from corresponding long-term measures in duration, focus, and intensity.

Long-term measures are described in more detail in the following chapter. Their measure-specific advantages and disadvantages are evaluated in subsequent chapters, and some are ultimately used to compose the water supply/water conservation plan.

Tables 4 and 5 also identify contingent measures. These may include measures that are not acceptable on a long-term basis but are "potentially" acceptable when applied for a short time under severe drought conditions. They may also include potential long-term measures which are not ultimately included in the water supply/water conservation plan. Special considerations such as heightened

TABLE 4

POTENTIAL WATER CONSERVATION MEASURES - URBAN CORE COMMUNITIES

	Applicable	Technically Feasible	Socially Acceptable
MANAGEMENT MEASURES			
Long-Term			
Metering	No		
Meter Maintenance	Yes	Yes	Yes
Pressure Regulation	No		
Leak Detection and System Maintenance	Yes	Yes	Yes
Average Demand Pricing Structures			
- Marginal Cost	No		
- Uniform Unit	No		
- Increasing Unit	No		
Peak Demand Pricing Structures			
- Daily Peak Load	Yes	Yes	Yes
- Seasonal Surcharge	Yes	Yes	Yes
- Excess Use Charge	Yes	Yes	Yes
- Declining Block	No		
Other Pricing Measures			
- Demand Charges	No		
- Hook-Up Fees	Yes	Potentially	No
Economic Incentives			
- Tax Credits	Yes	Yes	Yes
- Rebates	Yes	Yes	Yes
- Subsidies	Yes	Yes	Yes
Water-Saving Devices			
- Fixtures for New Construction	Yes	Yes	Yes

TABLE 4 (continued)

POTENTIAL WATER CONSERVATION MEASURES - URBAN CORE COMMUNITIES

	Applicable	Technically Feasible	Socially Acceptable
MANAGEMENT MEASURES (continued)			
Long-Term			
Water Saving Devices (continued)			
- Free Distribution of Retrofit Conservation Kits (includes leak detection supplies)	Yes	Yes	Yes
- Free Distribution and Installation of Retrofit Devices	Yes	Yes	Yes
- Devices for Residential Irrigation			
Moisture Sensors	Yes	Potentially	No
Hose Meters	Yes	Potentially	Yes
Sprinkler Timers	Yes	Potentially	No
Industrial Process Modifications	Yes	Potentially	Yes
Re-Use of Municipal Wastewater Effluent	Yes	No	
Re-Use of Municipal Process Water	No		
Contingent			
Pricing			
- Penalty Charges	Yes	Potentially	Potentially
REGULATORY MEASURES			
Long-Term			
Federal Regulations	No		
State Regulations			
- Minnesota	No		
- North Dakota	No		
- Regulations regarding Agricultural Irrigation	No		

TABLE 4 (continued)

POTENTIAL WATER CONSERVATION MEASURES - URBAN CORE COMMUNITIES

	Applicable	Technically Feasible	Socially Acceptable
REGULATORY MEASURES (continued)			
Local Codes and Ordinances			
- Plumbing Codes	Yes	Yes	Yes
- Sprinkling Ordinances	Yes	Yes	Yes
- Changes in Landscape Design	Yes	Potentially	No
- Residential Water Recycling	No		
Contingent			
Local Codes and Ordinances			
- Retrofitting Ordinances	Yes	Yes	No
Restrictions Rationing Use			
- Prior Use Basis	Yes	Yes	No
- Fixed Allocation	Yes	Yes	Potentially
- Per Capita Use	Yes	Yes	Potentially
- Variable Percentage	Yes	Yes	Potentially
Restrictions Determining Priority Use			
- Banned Wasteful Practices	Yes	Yes	Potentially
EDUCATIONAL MEASURES			
Long-Term and Contingent			
Direct Mail	Yes	Yes	Yes
News Media	Yes	Yes	Yes
Personal Contact	Yes	Yes	Yes
Special Events	Yes	Yes	Yes

TABLE 5

POTENTIAL WATER CONSERVATION MEASURES - RURAL COMMUNITIES

	Applicable	Technically Feasible	Socially Acceptable
MANAGEMENT MEASURES			
Long-Term			
Metering	Yes	Yes	Yes
Meter Maintenance	Yes	Yes	Yes
Pressure Regulation	No		
Leak Detection and System Maintenance	No		
Average Demand Pricing Structures*			
- Marginal Cost	No		
- Uniform Unit	No		
- Increasing Unit	No		
Peak Demand Pricing Structures*			
- **Daily Peak Load**	Yes	Yes	Yes
- **Seasonal Surcharge**	Yes	Yes	Yes
- **Excess Use Charge**	Yes	Yes	Yes
- Declining Block	No		
Other Pricing Measures*			
- Demand Charges	No		
- Hook-Up Fees	Yes	Potentially	No
Economic Incentives			
- **Tax Credits**	Yes	Yes	Yes
- **Rebates**	Yes	Yes	Yes
- **Subsidies**	Yes	Yes	Yes
Water-Saving Devices			
- **Fixtures for New Construction**	Yes	Yes	Yes
- **Free Distribution of Retrofit Kits** (includes leak detection supplies)	Yes	Yes	Yes
- **Free Distribution and Installation of Retrofit Devices**	Yes	Yes	Yes
- Devices for Residential Irrigation			
Moisture Sensors	Yes	Potentially	No
Hose Meters	Yes	Potentially	Yes
Sprinkler Timers	Yes	Potentially	No

TABLE 5 (continued)

POTENTIAL WATER CONSERVATION MEASURES - RURAL COMMUNITIES

MANAGEMENT MEASURES (continued)	Applicable	Technically Feasible	Socially Acceptable
Long-Term			
Industrial Process Modifications	Yes	Potentially	Yes
Re-Use of Municipal Wastewater Effluent	Yes	No	
Re-Use of Municipal Process Water	No		
Contingent			
Pricing			
- Penalty Charges	Yes	Potentially	Potentially
REGULATORY MEASURES			
Long-Term			
Federal Regulations	No		
State Regulations			
- Minnesota	No		
- North Dakota	No		
- Regulations Regarding Agricultural Irrigation	No		
Local Codes and Ordinances			
- Plumbing Codes	Yes	Yes	Yes
- Sprinkling Ordinances	Yes	Yes	Yes
- Changes in Landscape Design	Yes	Potentially	No
- Residential Water Recycling	No		
Contingent			
Local Codes and Ordinances			
- Retrofitting Ordinances	Yes	Yes	No
Restrictions Rationing Use			
- Prior Use Basis	Yes	Yes	No
- Fixed Allocation	Yes	Yes	Potentially
- Per Capita Use	Yes	Yes	Potentially
- Variable Percentage	Yes	Yes	Potentially

TABLE 5 (continued)

POTENTIAL WATER CONSERVATION MEASURES - RURAL COMMUNITIES

REGULATORY MEASURES (continued)	Applicable	Technically Feasible	Socially Acceptable
Contingent			
Restrictions Determining Priority Use			
- Banned Wasteful Practices	Yes	Yes	Potentially
EDUCATIONAL MEASURES			
Long-Term and Contingent			
Direct Mail	Yes	Yes	Yes
News Media	Yes	Yes	Yes
Personal Contact	Yes	Yes	Yes
Special Events	Yes	Yes	Yes

NOTE: A star (*) indicates that this group of pricing measures is still applicable for Glyndon and Sabin.

public awareness and cooperation during drought conditions can affect the effectiveness of these measures. These special considerations and interactions with long-term measures warrant a separate analysis for contingent measures. It takes place after long-term measures are selected for the water supply/ conservation plan; the contingent measures are then incorporated into the drought emergency plan. As such, they provide added assurance that the proposed water supply/water conservation plan meets and exceeds the demands of a 50-year drought in the year 2030 and beyond.

V. POTENTIAL WATER CONSERVATION MEASURES

Tables 4 and 5 in the previous chapter summarize the results of applying the three criteria required for potential water conservation measures: applicability, technical feasibility, and social acceptability. Thus, they define the potential water conservation measures for the urban core and rural communities. In the following discussion, the potential water conservation measures are described in detail. Implementation plans are also addressed, including a discussion of recognized constraints or impediments to implementation and an implementation schedule.

A. METERING

Metering is a long-term conservation measure applicable in the rural communities of Glyndon and Sabin, Minnesota. This measure relies on changes in consumer water use practices to conserve water. Under conventional flat-rate billing methods, the consumer has no incentive to conserve because the same fee is paid no matter how much is used. Metering provides the means of charging a consumer for the quantity used and links cost directly to this quantity. Lawn sprinkling is the primary source of reductions due to metering (Flack, 1977). The amount of lawn sprinkling depends on climate, water price, billing system, and consumer income (Flack, 1977). Therefore, potential reductions in study area communities are also influenced by these factors.

All consumers would be directly affected by the installation of a meter, a new price structure, and a new billing format. Metering often means higher water bills, and this has a negative social impact even though the measure is equitable. In addition, this measure represents an irreversible decision, with a relatively high initial cost and periodic maintenance or meter replacement. These effects tend to decrease the public support for metering. Elected

officials could consider metering too costly because no new water is made available and alternatively favor the development of new sources (Green, 1972 in Flack, 1977). Therefore, the cooperation and support of local government are critical to this measure. A pricing structure must also be implemented as part of metering. The U.S. Army Corps of Engineers social acceptability study offers information about pricing. Briefly, the survey indicates that consumers must be convinced of the need for conservation before the majority would support it.

The municipal water department would be responsible for the installation and monitoring of meters, as well as the billing process. The city officials would be responsible for initiating the rate study, deciding whether to meter, and determining which price structure and price levels to adopt.

The implementation schedule must include adequate lead time to address the concerns of the public and set aside funds for the purchase and installation of meters. One year is allotted for initiating these activities, though a longer period may be appropriate, depending on utility revenues. It is assumed that the entire service area would become metered over a period of five years.

B. METER MAINTENANCE

A systematic meter maintenance and replacement program is a long-term measure that is also a demand management conservation measure. It is applicable in all metered communities. This measure conserves water by ensuring that all consumers pay for the full amount of water they use. Misregistering or broken meters that underestimate flows are often unreported. For meters with more than 8 to 10 years of service, at least 20 percent will not register flows below 0.75 gpm, and up to 23 percent of all domestic use is estimated to be at or below this level (Hudson, 1978 in AWWA, 1980). Hence, meter maintenance

increases the water bills of affected consumers, and they respond by reducing their consumption. Meter maintenance is generally well-received by the public. Significant costs may be borne by the utility, depending on the scale and schedule of the maintenance program; however, these costs are mitigated by the revenues associated with the increase in billable water.

The municipal water department would be responsible for implementing the measure. Some training may be required for the additional personnel required to calibrate meters. Residential meters would be calibrated once every 10 years; commercial meters, once every two years; and industrial meters and utility master meters calibrated annually. Meters failing to calibrate would be repaired or replaced. It is assumed that all meters would have to be replaced after 20 years. The implementation schedule assumes the measure would be initiated immediately.

C. LEAK DETECTION AND SYSTEM MAINTENANCE

Leak detection is a long-term measure that would continue throughout the entire study period. The measure reduces water lost through leakage and increases the water supply accordingly. Since it is also a supply management conservation measure, utilities can implement this measure without directly affecting customers. Leak detection is likely to be well accepted socially and politically, and no impediments to implementation are anticipated.

A leak detection program can generally be justified if unaccounted-for water is greater than 15 percent (AWWA, 1981). On this basis, the community considered to benefit most from this measure is Fargo. Their municipal water department would be responsible for training two people to use hand-held sonic listening devices to locate leaks. A cross-section of the city may be examined to establish priority areas, or the detection procedure may begin in the portion of

the community with the oldest pipe. Located leaks are charted and evaluated for subsequent repair. Analyses of the associated costs will help to prioritize system repairs. The measure could be implemented immediately although it would take approximately two years to survey the entire city.

D. PRICING

Pricing is a long-term water conservation measure. All communities in the study area have adopted conservation-oriented pricing structures, with the exception of the unmetered communities of Glyndon and Sabin, Minnesota (see Chapter III). Because of the two unmetered communities, the full range of pricing measures has been retained as potential measures for the rural communities. Potential pricing measures for all other urban and rural communities are shown in Table 1. Some of these measures are compatible with the existing declining block or uniform unit pricing structures and are described below.

Pricing measures conserve water by changing consumer water use practices. Price levels and/or structures are adopted that often involve increased charges for water used during periods of high demand. Pricing measures can quickly become an active political issue, because consumers are often concerned that they may be adversely affected by changes in pricing methods, and all consuming sectors could be affected. Therefore, a rate study must be conducted to determine the economic impacts of the measure, and the public must be accurately informed about the need for pricing changes and the associated consumer costs.

A key factor in the choice of potential pricing measures is social acceptability. The U.S. Army Corps of Engineers has conducted a study of the social implications generally associated with pricing measures. This information indicates that although the public believes pricing to be effective, it opposes pricing structures where the cost per unit increases with consumption

(for example, increasing block structure). It also indicates that the more people know about this method of pricing, the less they favor it. Other studies indicate that social acceptability depends on familiarity and equitability. The social acceptability of pricing generally increases when consumers are more familiar with it (Lord and others, 1983). The pricing measures must also be equitable; the billing rates must be related to the costs of supply and costs must be borne by those who incur them (U.S. Army Corps of Engineers, 1981).

Considering these factors of social acceptability, the most socially acceptable measure would directly address the water supply needs of the community, be familiar to the consumer, and apportion costs equitably. Also, the most acceptable measure would probably not have a structure similar to the inclining block, as outlined above. The Phase 2 water supply study for the Fargo-Moorhead area indicated that in most communities water supply deficits occur for relatively short periods during times of peak demand or drought. In these cases, a peak demand pricing measure compatible with the existing conservation-oriented pricing structure is appropriate. Of the peak demand pricing measures shown in Tables 4 and 5 - Potential Water Conservation Measures, peak load, seasonal surcharge, and excess use charges are all possibilities. Since peak load pricing requires expensive metering, either a seasonal surcharge, or excess use charge would be the best choice. The surcharge would least resemble a structure similar to the inclining block.

Several communities may encounter both peak and average water supply shortages over the planning period. Dilworth is a notable example. The uniform unit pricing structure the city has adopted is compatible with any of the peak demand structures and may be adapted to implement them.

Both a seasonal surcharge and an excess use charge could easily become familiar to consumers, because they could be used in conjunction with the existing declining block pricing structure. Large volume users consider these structures equitable. Excess use charges would be applied to consumption in excess of 130 percent of normal winter use. Only consumers with "excess use" would be affected. A seasonal surcharge would spread costs over all users throughout the period of heavy "seasonal" use. Either of these two structures is anticipated to be equally effective, assuming appropriate price levels.

As with the metering measure, the implementation schedule must include adequate lead time to address the concerns of the public and demonstrate the need for a pricing measure and its capability to conserve water. The actual application of the revised pricing structure would be proceeded by at least a 1-year period of evaluation. During this period, a rate study would be conducted to determine the need for a revision and to examine the appropriate changes. This study would investigate price elasticity of demand and the effects on revenues and customer bills. Then, an eduction/public relations campaign would follow to familiarize consumers with potential peak demand pricing changes. This campaign would include bill inserts, conservation brochures, handouts, and newsletters. When the measure is finally activated, it can be viewed as a long-term measure applied annually affecting all consumers during periods of peak demand.

Penalties involve a fine or surcharge assessed to consumers which do not conserve. A penalty plan is proposed as part of the drought emergency plan in Chapter XI. Penalties are detrimental to the public image of the utility or administering body, and the conservation effort in general. Therefore, they

should only be applied in severe water shortages or flagrant violations. Accordingly, this measure will be considered further as a contingent water conservation measure.

E. ECONOMIC INCENTIVES

Economic incentives are considered as long-term management policy options that encourage other conservation practices with monetary rewards or penalties. Penalties are considered only potentially socially acceptable for the purposes of our study (see Chapter IV). Positive incentives are highly acceptable to consumers and effective if they are substantial enough to produce a real behavorial response (Lord and others, 1983). Economic incentives are used to promote other measures, most notably, the installation of water-saving devices. The incentive could be implemented immediately for new construction.

Economic incentives could be in the form of a local one-time tax credit, a building permit rebate, or some other type of subsidy. In this study, incentives are used to encourage the installation of water-conserving appliances in new construction. This measure will affect housing units in the residential and commercial sectors. Commonly, the installation of water-saving appliances is implemented with a locally initiated change in the building or plumbing code. However, in Minnesota, recent State court rulings have not upheld stricter revisions of building codes by local governments (Milt Bellin, Minnesota State Department of Health, 1984), thereby necessitating the use of economic incentives. Though the incentive is initiated and managed by the municipality, the utility would probably share the costs.

An economic incentive equivalent to 40 percent of a water conservation expenditure has been indicated to motivate 50 percent of those affected to undertake the desired action (Lord and others, 1983). Specifically, these costs

would include 40 percent of the additional cost of water-saving appliances over regular fixtures. These appliances could include shallow trap toilets, low-flow showerheads, or more major water-saving fixtures.

Penalities may be thought of as negative economic incentives or pricing measures. This study addresses them as contingent pricing measures. In either case, penalties are only potentially socially acceptable. This classification means that a measure is only acceptable under conditions associated with severe drought.

F. WATER-SAVING DEVICES

Three variations of the long-term water-saving device measure are considered as potential water conservation measures. Water-saving fixtures in new construction is compatible with either of the two remaining variations: free distribution of retrofit conservation kits and free distribution and installation of retrofit devices. The latter two variations are mutually exclusive. Initially, devices for residential irrigation were considered, but they were judged to be technically infeasible or socially unacceptable.

Water-saving devices are also demand-management water conservation measures. These measures affect domestic water use in residential and commercial sectors. Consumer lifestyles may be slightly affected by these measures, because certain characteristics of the flow of water from conserving fixtures may differ from the flow with regular fixtures. The U.S. Army Corps of Engineers has conducted a study of the general social implications of this type of conservation measure. This study indicated that the people of the study area are fairly knowledgeable about water-saving devices and that they perceive them as economical and effective. Therefore, measures utilizing water-saving devices would probably be

well-accepted by consumers under non-drought conditions. Education is vital to the implementation of this measure in two ways: to gain the political support to make the required code revisions or fund economic incentives, and to encourage consumers to install the fixtures or devices.

The measure utilizing water-saving fixtures for new construction could be implemented with a revision of the plumbing portion of the local building code. An economic incentive may also be used. However, codes were the most popular method of implementation according to the U.S. Army Corps of Engineers' survey. In this study, the required local revision of building codes is possible only in North Dakota, so Minnesota communities have been assumed to use economic incentives to implement this measure. These economic incentives could include tax credits, subsidies, or rebates as previously discussed.

Water-saving fixtures is a long-term measure which would increase in effectiveness with the number of housing units using the fixtures. The municipal government would be primarily responsible for implementing this measure. The plumbing portion of the local building code would stipulate maximum flows for fixtures like toilets, showerheads, and faucets. Sample plumbing codes are offered by the U.S. Army Corps of Engineers (1981) and other sources. If economic incentives are employed to implement this measure, an economic analysis may be required to choose the most efficient means of initiating the installation of these water-saving fixtures. Inspection for compliance could be accomplished with little additional effort by using the existing inspection system.

Free distribution of retrofit kits could be initially implemented on short notice, requiring only time for advance publicity. A local service organization or student groups could be used for the packaging and distribution of kits. One kit would include:

3 toilet water displacement dams
1 low-flow faucet aerator
1 plastic flow-reducing button for insertion into regular aerating faucets
1 plastic flow-reducing button for insertion into a shower line
1 booklet of water-saving tips, including installation instructions
1 water conservation brochure describing local efforts

After the initial distribution, retrofit kits would be available at a local distribution depot for a very minimal cost. The installation of retrofit devices could be promoted periodically throughout the study period utilizing depot distribution. For example, a drought during the study period would be an opportune time for a promotion.

The free distribution and installation of water-conserving devices would follow the same implementation plan as the previous variation of the measure. However, installation would increase the initial cost of the measure. Installation could be conducted by people with only minimal training. Equipment costs such as tools necessary to outfit the people installing devices would be minimal.

G. INDUSTRIAL PROCESS MODIFICATIONS

Conservation by industrial process modification is a difficult matter to address. Each individual industry would require a detailed analysis of their specific processes, and the scope of this study does not permit this type of evaluation. In general, industry is quite responsive to changes in price and continually tends to reduce its water use through recycling and re-use as costs increase. The changes in water use associated with changes in water price could be addressed as part of a rate study like those involved in several of the other potential water conservation measures.

The two major industrial water users in the study area are the American Crystal Sugar factory and the Anheuser-Busch malt plant in Moorhead. The American Crystal Sugar factory is presently conducting a re-use/recycle study. The company feels that reductions in municipal water use of up to 50 percent may be feasible. One promising process modification involves the increased use of water condensate for an ion exchange system and boiler feed water. The Anheuser-Busch malt plant was built in 1979, making it one of the more modern facilities of its type. The plant design employs some of the most energy- and water-efficient processes and equipment available to the industry.

H. LOCAL CODES AND ORDINANCES

Local codes and ordinances include long-term and contingent water conservation measures. A local sprinkling ordinance is a long-term measure used to restrict landscape irrigation to selected days and times. Local codes and ordinances also include State regulations that have been adopted by local governments, if local governments are empowered to make conservation-oriented revisions. North Dakota State Plumbing Codes are adopted by local governments under these conditions. Therefore, the revisions in plumbing codes which were previously described in the discussion on implementing water-saving devices in new construction could also be considered a local code and ordinance measure. A retrofitting ordinance is a possible contingent measure. This measure would require retrofitting of commercial and residential housing units with retrofit kit devices like those described in the discussion of water-saving devices. Such an ordinance would probably be unenforceable and could be viewed by many as a violation of privacy. Since other means of retrofitting are generally well accepted, this regulatory measure has been dropped from further consideration.

Consumers are directly affected by sprinkling ordinances. Their lifestyles may be slightly altered by the restricted times that they may have to be home to water their lawns. Special interest groups may also oppose the measure on aesthetic grounds, although no adverse effects are anticipated for lawns and shrubberies under the proposed restrictions.

The U.S. Army Corps of Engineers social acceptability study offers additional information about this general type of measure. The study indicated that residents of the study area feel that significant and cost-effective reductions in water use may be obtained by reducing lawn irrigation. The cost-effectiveness of this measure was a particularly important factor in the public determination of acceptance. The public believes that a "serious" water supply shortage should occur before they were asked to reduce their outdoor use by 50 percent.

The particular sprinkling ordinance considered as a potential measure would not directly limit the amount of water for irrigation. The measure calls for sprinkling to be restricted to between 8 p.m. and 10 a.m. on alternate days. Since evapotranspiration losses are reduced during these hours, less water is required. It is probable that lifestyle conflicts will shorten actual sprinkling time even further.

These sprinkling ordinances are considered long-term conservation measures. Though they may be used only for short periods, the ordinances would be adopted once by the municipal government and then enforced for residential and commercial users during periods of water shortage throughout the period of study. A multi-step enforcement plan similar to the plan proposed in the drought emergency section may be appropriate. The plan could include a series of warnings and surcharges for repeated violations.

I. RESTRICTIONS RATIONING USE

Three variations of rationing restrictions are considered as potential water conservation measures: fixed allocation, per capita use, and variable percentage rationing. These rationing programs are all viewed as equally effective measures. Rationing based on prior use is not considered a potential measure. This type was determined to be socially unacceptable since it is believed to be inequitable. Knowledgeable local authorities believe that rationing on a prior use basis punishes those who are already conserving.

Rationing could have a major effect on consumers' lifestyles and would be acceptable only under conditions associated with serious water shortages like those of the 50-year drought. Therefore, rationing measures are considered as "contingent" water conservation measures. Accordingly, contingent measures are evaluated as components of the drought emergency plan. Since the effectiveness under drought emergency conditions depends heavily on the long-term measures already implemented, the analysis of contingent measures will follow the selection of the long-term measures.

The local government and drought action team (see Chapter VI) would be responsible for determining when to implement the measure. The municipal government would implement rationing measures by officially adopting some form of drought emergency plan and then enacting the elements of the plan under designated drought conditions. Minnesota State Statute 105.418 requires public water suppliers to adopt and enforce this type of conservation regulation. Contingent measures would be passed and repealed for each crisis.

Enforcement may be achieved using water utility or police personnel. A system of penalties like those proposed in the drought emergency plan may be appropriate. In addition, a review board composed of elected officials and

utility personnel would be required to review complaints related to equitability. Interviews with local utility personnel indicate that per capita or fixed allocation rationing measures are more favorable than a more complicated variable percentage plan. Contingent measures are considered in detail in Chapter XI with the Drought Emergency Plans.

J. RESTRICTIONS DETERMINING PRIORITY USE

Restrictions that determine priority use are contingent water conservation measures. Restrictions such as banning wasteful practices conserve water by forbidding certain uses. Commonly, outdoor uses such as irrigation and car washing are banned. Residential and commercial sectors are the primary areas affected. These restrictions are appropriate only as a last resort to extend the supply capabilities beyond the 50-year recurrence interval event. Water use bans are not as socially acceptable as rationing because bans are less flexible. Bans prohibit certain uses, whereas rationing allows users to do as they wish with their allocation. Also, a partial ban on a specific use is not feasible, but varying levels of rationing may be considered.

The local government and drought action team (see Chapter XI) would be responsible for determining when to implement the measure. The public must be kept informed about the communities' water supply status so that when conditions become severe, they will see the need for the measure. Enforcement may be accomplished using methods like those described for rationing.

A ban on outdoor use would have such a major impact on consumers that it would not be socially acceptable except under severe drought conditions. A ban could damage turf, shrubberies, and possibly shallow-rooted trees. This measure will be evaluated with other contingent measures after the long-term conservation

measures have been determined. This measure would be implemented in the same manner as previously discussed for contingent measures.

K. EDUCATION

There are many variations to the educational measures displayed in Tables 4 and 5. Commonly, a combination of selected educational measures is employed. These measures may be used to help implement other types of conservation measures or they may be considered a measure in themselves. In the latter case, conservation reductions are obtained by convincing consumers to change their water use practices.

Direct mail brochures or billing inserts can explain wasteful water use practices and encourage a change in lifestyle. Though the consumer would be directly affected by this type of measure, education is generally very well received. The U.S. Army Corps of Engineers social acceptability study supports this statement. Their study indicates that education would be an acceptable long-term or contingent water conservation measure. Education is a vital part of the proposed drought emergency plans.

No special actions are required to implement education measures. Municipal governments and utilities already have well-established channels of communication with the public. Feedback from consumers commonly comes through local newspapers and city council members.

L. SUMMARY OF POTENTIAL WATER CONSERVATION MEASURE IMPLEMENTATION CONSIDERATIONS

Table 6 presents a summary of implementation considerations for each of the potential measures discussed. It includes specific information such as an implementation schedule and the assumed coverage and duration for each measure.

TABLE 6

IMPLEMENTATION OF POTENTIAL WATER CONSERVATION MEASURES

Measure	Implementation Schedule	Coverage and Duration
Management Measures		
Metering	Begin funding with utility revenues in 1984. Begin meter installation in 1985. Complete 100 percent in 1990.	Rural Communities. Covers 100 percent of Glyndon and Sabin service areas. Long-term measure. Impacts residential and commercial sectors.
Meter Maintenance	Begin in 1985. Complete residential inspections every 10 years. Commercial inspections every 2 years.	Urban Core Communities. Long-term measure. Reduces unaccounted-for and public sector use and increases other sectors' use by the amount of mis-registration.
Leak Detection and System Maintenance	Leak detection, repair, and rehabilitation begins in 1985 and continues throughout the study period.	Urban Core Communities; Covers 100 percent of Fargo service area. Long-term measure. Impacts unaccounted-for and public sector.
Pricing		
- Average Demand Pricing	Implementation begins with rate study in 1985. Revised pricing structure in place in 1990.	Rural Communities. Long-term measure. Impacts all water users.
- Peak Demand Pricing	Implementation begins with rate study in 1985. Revised pricing structure in place in 1990.	Urban Core and Rural Communities. Long-term measure. Impacts all seasonal water users.
Economic Incentives	Used to facilitate implementation of other measures (see text).	
Water-Saving Devices		
- Fixtures for New Construction	Implemented in all new construction after 1985.	Urban Core and Rural Communities. Long-term measure. Impacts new construction in residential and commercial sectors.

TABLE 6 (Continued)

IMPLEMENTATION OF POTENTIAL WATER CONSERVATION MEASURES

Measure	Implementation Schedule	Coverage and Duration
Management Measures (continued)		
Water-Saving Devices (continued)		
- Retrofit Distribution	Implemented in 1985 with door-to-door distribution. Periodic promotion of retrofit kits and depot distribution continue throughout study period.	Urban Core and Rural Communities. Long-term measure. Impacts residential and commercial sectors.
- Retrofit Distribution and Installation	Implemented in 1985 with door-to-door distribution and installation. Periodic promotion of retrofit kits and depot distribution continue throughout study period.	Urban Core and Rural Communities. Long-term measure. Impacts residential and commercial sectors.
- Industrial Process Modifications	Already widely implemented. Complete implementation coverage and duration is beyond scope of this study (see text).	
Regulatory Measures		
Local Codes and Ordinances		
- Plumbing Codes	Used to facilitate implementation of other measures in North Dakota only (see text).	
- Sprinkling Ordinances	Implemented in 1985.	Urban Core and Rural Communities. Long-term measure. Impacts residential and commercial seasonal use.
Educational Measures		
	Implemented in 1985 and continuing throughout study period.	Urban Core and Rural Communities. Long-term measure. Impacts residential and commercial sectors.

An important factor in implementation is the cooperation between the water utility and the municipal government. Most water utilities in the study area are publically/municipally-owned and may have water sales revenues supplemented with local government subsidies. Their budget is usually determined by the municipality. Thus, close cooperation already exists between the government and the utility.

The Cass Rural Water Users Association (CRWUA), however, is investor-owned. It serves rural communities in bulk or makes contracts with individual homeowners. The CRWUA relies solely on metered water sales for revenue. This relationship creates special considerations for implementation in those communities (Frontier, North River, and part of Reile's Acres) where the customer contracts directly with the CRWUA. In those communities and in communities with individual homeowner wells, water-saving devices and education may be the only appropriate water conservation measures; the conservation initiative would rest with the individual.

VI. EFFECTIVENESS EVALUATIONS OF POTENTIAL MEASURES

A. SUMMARY OF DISAGGREGATED WATER DEMANDS

As part of the Phase 2 study, disaggregated water demand forecasts were developed to examine alternative water supply plans. In Phase 3, it was necessary to expand these data for the purpose of determining the effectiveness of each water conservation measure. Additional estimates were made for five dimensions of demand (average day use, maximum day use, seasonal and non-seasonal use, average day consumptive use, and average day sewer contribution) for each sector such as residential and commercial. The five dimensions of demand were required because water conservation measures may affect dimensions of demand (and therefore costs) in different ways. For example, sprinkling ordinances will have a large effect on maximum day use, a lesser effect on average annual day use, and no effect on average day sewer contribution. Water-saving devices, on the other hand, may affect all three dimensions to the same degree. These estimates are based on aggregate and disaggregated water demand forecasts for each community in the Phase 2 study and are developed based on the methodology described in the following section.

1. Methodology of Disaggregated Forecasts

In order to estimate each component of the disaggregated forecasts, equations were developed and utilized to model the water use from the water treatment plant to the sewage treatment plant or final consumptive use. These relationships, shown below, have been used to develop the water use by dimension for each sector, as well as the total water use for each community. Water demand projections from Phase 2 provide average day usages and most of the information required to calculate the other dimensions of water use. Maximum

day use for each of the sectors had to be developed and average day sewer flow had to be determined to estimate consumptive, non-seasonal, and seasonal use.

The maximum day usage for each water use sector may not coincide with the day of maximum municipal use. Municipal maximum day use in most study area communities occurs in July or August. Industrial and commercial use is actually less than annual average use during these two months because the Crystal Sugar plant is not in production and the colleges have a significantly lower summer enrollment. Therefore, seasonal distributions of water use were constructed for the different sectors from utility data. These values were then used to partition Phase 2 aggregated municipal day uses among the different sectors for the municipal maximum day.

The means of preparing projected uses for the dimensions of water use are summarized as follows:

Average Day Sewer Contribution: from Facilities Plans, Infiltration and Inflow (I/I) Analyses, and Demand Projections

Return Flow = Average Day Sewer Contribution + I/I + Sewered Private Water Sources + Miscellaneous Sources (e.g., Dilworth's Average Day Sewer Contribution to the Moorhead plant)

Total Consumptive Use = Average Annual Day Use - Average Day Sewer Contribution

Seasonal Use = Total Consumptive Use - (Public + Unaccounted-for Uses) - Cooling Water

Contributions to sewer flow are based on data contained in the community's Infiltration/Inflow (I/I) Analysis and Facilities Plan and on estimates using projected populations and existing return-flow percentages. Average day sewer contributions, as noted above, are developed from existing wastewater flow data as well as future projections. They consider both existing and projected infiltration/inflow.

Total consumptive use includes three components: seasonal use (primarily residential irrigation), unaccounted-for and public uses, and cooling water. Return flows are sewer contributions from municipal consumers plus infiltration/inflow, sewered private wells, and miscellaneous uses. Consumptive uses are essentially those water demands that will not be returned to area rivers as return flows from wastewater treatment facilities. In calculating consumptive use, the entire unaccounted-for and public use is considered consumptive because consumptive uses, including water lost through breaks in the distribution system, hydrant flushing, fire fighting, and public irrigation dominate this sector's use. Non-consumptive unaccounted-for and public use is composed of water used inside public buildings. Most larger buildings that might be considered "public," such as schools, are metered and included in the commercial sector's water use. Seasonal use is one component of consumptive use that merits particular attention. For the purposes of this report, seasonal use is assumed to be the difference between the maximum day use and average annual day use.

2. Summary of Disaggregated Forecasts

For each community, based on the methodology presented in the preceding section, disaggregated water and wastewater forecasts have been developed to aid in calculating effectiveness of each potential conservation measure. These forecasts are found in Appendix A. A summary of the disaggregated water and wastewater forecasts for the urban core and rural communities are presented in Tables 7 and 8, respectively. Total consumptive use has been broken out by seasonal, unaccounted-for and public, and cooling water use in these tables and the appendix. Wastewater flow from Riverside is included in the urban core summary because it is discharged into the West Fargo treatment plant.

TABLE 7

SUMMARY OF DISAGGREGATED WATER AND WASTEWATER USE - URBAN CORE COMMUNITIES
(million gallons per day)

	Projected Water Use						Projected Wastewater Use
	Average Annual Day Use	Maximum Day Use	Seasonal Use	Unaccounted-for and Public	Cooling Water	Total Consumptive Use	Average Day Sewer Contribution
Year 2000							
Residential	6.506	28.825	2.380	3.302	--	5.682	6.276
Commercial	6.563	7.328	0.075	0.673	--	0.748	6.876
Industrial	2.600	2.340*	0.010	0.030	0.430	0.470	2.182
Miscellaneous (Private Supply)	--	--	--	--	--	--	0.715
Unaccounted-for and Public	4.005	4.545	0.050	--	--	0.050	--
Processing Water	1.230	1.590	--	--	--	--	--
Total	20.904	44.628	2.515	4.005	0.430	6.950	16.049
Year 2030							
Residential	8.213	35.827	2.808	4.121	--	6.929	7.709
Commercial	8.441	9.246	0.078	0.954	--	1.032	8.863
Industrial	2.980	3.590	0.110	0.040	0.530	0.680	2.374
Miscellaneous (Private Supply)	--	--	--	--	--	--	--
Unaccounted-for and Public	5.115	5.685	0.060	--	--	0.060	--
Processing Water	1.500	2.080	--	--	--	--	--
Total	26.329	56.428	3.056	5.115	0.530	8.701	19.698

*Industrial flows on day of municipal maximum use may be less than average annual industrial demands because day of municipal maximum use will occur in dry season when a major industry is not in production.

TABLE 8

SUMMARY OF DISAGGREGATED WATER AND WASTEWATER USE - RURAL COMMUNITIES
(million gallons per day)

	Projected Water Use						Projected Wastewater Use
	Average Annual Day Use	Maximum Day Use	Seasonal Use	Unaccounted-for and Public	Cooling Water	Total Consumptive Use	Average Day Sewer Contribution
Year 2000							
Residential	0.320	0.675	0.064	0.035	--	0.099	0.269
Commercial	0.032	0.066	0.006	0.002	--	0.008	0.031
Industrial	0.012	0.024	--	--	--	--	--
Miscellaneous (Private Supply)	--	--	--	--	--	--	--
Unaccounted-for and Public	0.037	0.037	--	--	--	--	--
Total	0.401	0.802	0.070	0.037	--	0.107	0.300
Year 2030							
Residential	0.421	0.889	0.078	0.048	--	0.126	0.354
Commercial	0.043	0.089	0.009	0.002	--	0.011	0.039
Industrial	0.024	0.048	--	--	--	--	--
Miscellaneous (Private Supply)	--	--	--	--	--	--	--
Unaccounted-for and Public	0.050	0.050	--	--	--	--	--
Total	0.538	1.076	0.087	0.050	--	0.137	0.393

B. REPORTED EFFECTIVENESS OF POTENTIAL MEASURES

The effectiveness of potential measures are estimated from published studies of conservation practices, reports on community conservation efforts, and manufacturer's reports and field test data on water conservation devices and practices. The sources used and the effectiveness estimates obtained are presented below.

1. Metering

Estimates on effectiveness for metering a community which is unmetered, such as Glyndon and Sabin, Minnesota, were taken from a report in the ASCE Journal of the Water Resources: Planning and Management Division (Flack, 1981). This study shows total water demand can be reduced by 21 percent and seasonal use by 31 percent. In a handbook put out by the Colorado Water Resources Research Institute, water savings can be as high as 25 percent of total demand. Both Glyndon and Sabin have high seasonal water demands, and their average per capita water demand is approximately 20 percent greater than the average per capita demands in other rural communities. Because per capita non-seasonal use for both communities is consistent with the other rural communities, reductions are based on seasonal use. Seasonal use is assumed to be reduced by 31 percent for both residential and commercial sectors. The average annual day is reduced by 22 percent for residential and 20 percent for commercial sector demands. Maximum day sector use is assumed to be reduced by the same percentages (22 to 20 percent). The average day sewer contribution will remain unaffected because seasonal use reductions affect primarily lawn watering and other consumptive uses (car washing, garden watering, etc).

2. Meter Maintenance

Meter maintenance is difficult to evaluate because so little has been documented on the effectiveness of implementing this measure. The under-registration of meters would seem to be a substantial part of the unaccounted-for and public water. More than one in five meters in service over 10 years do not read flows less than 0.75 gpm, and generally 23 percent of the residential flow is less than this value (Hudson, 1978 in AWWA, 1980). A manufacturer of water meters (Rockwell International) has completed programs with municipalities where they have replaced 50 percent or more of their meters in a phased replacement program. The oldest meters are generally the target for replacement. They report that after four years, with more than 60 percent of the meters replaced, a 24-percent decrease in unaccounted-for water was achieved in a western Pennsylvania community. In a northern California community, a 30-percent decrease was noted after a meter replacement campaign. Similar examples are available, some more and some less successful. Much of the success depends on the percent of the unaccounted-for and public water already present in each community. Based on the Rockwell data, a reduction of 30 percent of the unaccounted-for and public water use was estimated for the communities in the study area. While reducing unaccounted-for water, meter replacement programs increase the amount billed to the local customers. The percentage increases are 30 percent times the existing percentage of unaccounted-for water. The response by the public is to curtail demand, similiar to the response to a price increase.

The price elasticity of demand is defined as the percentage change in water demand resulting from a one-percent change in price. As the price increases, the water demand decreases. Pricing elasticities for each sector were used to

estimate the effectiveness of the price increase on the water demand. These values, taken from a handbook on water conservation, are as follows (New England River Basin Commission, 1981):

	Elasticity (Dimensionless)
Residential (Seasonal)	-0.22
(Non-Seasonal)	-0.07
Commercial	-0.56

Based on the Rockwell example, communities averaging 10-percent unaccounted-for water may reduce this figure to 7 percent by implementing a meter maintenance program. The 3-percent reduction will be billed to customers who will respond by curtailing demand. Using the price elasticity figures above, seasonal residential demand is assumed to decline by (0.22 x 3) = 0.66 percent, non-seasonal residential demand by 0.21 percent, and commercial demand by 1.68 percent. Clearly, those communities with the largest percentages of unaccounted-for water stand to gain most.

3. Leak Detection and System Maintenance

The American Water Works Association created a committee in 1976 to promote and develop leak detection methods. As a result, much has been written on these methods and the reductions in water losses that can be realized. Many California communities have implemented leak detection programs because of the extensive droughts experienced in the late 1970s. The East Bay Municipal Utility District (EBMUD) leak detection program increased the total water available by 3 percent through finding and repairing leaks. However, information about reductions in total use is not as extensive as reported

for reductions in unaccounted-for use. A program by the Westchester Joint Water Works (WJWW) in Mamaroneck, New York, reported reductions in unaccounted-for water of over 30 percent. More commonly, leak detection programs report reductions in unaccounted-for water of 10 to 30 percent, depending on the distribution system condition and age, and the types of repair needed (AWWA, 1981).

As noted in Chapter V, leak detection and system maintenance are justified only when unaccounted-for water exceeds 15 percent of total usage. Fargo is the only community known to qualify. It is difficult to determine exactly how much water is lost through system leaks such as water mains, service lines, and fire hydrant leaks, and how much is unaccounted-for for other reasons. For the purposes of this study, it is reasonable to assume that 10 percent of the unaccounted-for and public water can be found and eliminated through a leak detection and maintenance program.

4. Pricing

The seasonal rate increases associated with a peak demand pricing policy cause consumers to reduce consumption during this period. The exact amount of reduction depends on the price elasticity. Price elasticity is defined as the ratio of the relative change in commodity use to the relative change in price. Since elasticity varies between communities and with price level, average reductions based on literature are used to estimate the effectiveness of pricing in the study area. Based on "Water Conservation Management" (AWWA, 1981), and Achieving Urban Water Conservation, (Flack, 1977), residential seasonal use is estimated to decrease by 8 percent, residential non-seasonal use by 5 percent, and commercial use by 2 percent. These reductions in consumption reduce the total urban core average use and maximum day use by 3 and 9 percent,

respectively. These reductions are comparable to those produced utilizing the elasticity values reported for residential and commercial users in the meter maintenance measure with a price increase of approximately 30 percent.

The price increase could also help produce revenues necessary for capital improvements to meet future water demands. Actual price increases would be determined by rate studies conducted for each of the communities.

5. Water-Saving Fixtures

The water demand reductions obtained through water-saving fixtures are based on manufacturer's performance data. Domestic (interior) water use for the residential sector was divided into household uses as shown below:

Household Use	Percent of Total Use	Household Use (gallons)
Water Closet	40	55
Bath/Shower	30	43
Lavatory Sink	5	6
Laundry	15	22
Dishwashing	5	6
Drinking/Cooking	5	6
	100%	138 gallons

SOURCE: Achieving Urban Water Conservation, Flack, Weakley, and Hill, September 1977.

The typical household use of 138 gallons is consistent with the average use for the Fargo-Moorhead area residential sector. For each household use, the reduction of water use was calculated based on the manufacturer's field tests and publications of water-saving fixtures. For example, a shallow trap toilet will flush at 3.5 gpm and a normal trap toilet will flush at 5.0 gpm.

A 30-percent reduction (5.0 - 3.5)/(5.0) can be realized using the water-saving toilet. The potential reduction in demand (12 percent) is determined by combining this savings with the percentage of domestic use due to toilets

(30 percent x 40 percent). This is done for each household use with the aim of determining the total reduction in household use. The total reduction was calculated at 19 percent of the average domestic use for each household using the water-saving fixtures. These figures are substantiated by a Washington Suburban Sanitary Commission program which produced water savings of 12-20 percent in household use (New England River Basins Commission, 1981). Effectiveness for the Fargo-Moorhead area will increase every year as more homes are built and become affected by this measure.

Two methods are assumed in implementing the installation of water-saving fixtures. The first method, used in North Dakota, is simply a change in the plumbing code that makes water-saving fixtures mandatory in new construction. This is not possible in Minnesota, as explained in Chapter V, so an economic incentive is used to implement the measure. Some form of tax credit could be used to help the consumer pay part of the expense of water-saving fixtures. Past response to such programs indicates that 50 percent of the consumers would take advantage of this program (AWWA, July 1983). Thus, the effectiveness of Minnesota communities' water reductions would be half of the North Dakota communities. The ultimate overall effectiveness was calculated to be 2 percent of the average day use for the urban core communities and 4 percent for the rural communities.

6. Retrofit Distribution

Estimates of effectiveness for retrofit distribution were calculated using the same methodology as for water-saving fixtures. Manufacturers' performance data on equipment were used to determine possible reductions in household use.

The retrofit devices used for the effectiveness calculations are presented in Chapter V and consist of water closet displacement devices, showerhead inserts, and faucet aerators. Based on a water conservation program undertaken in East Brunswick, New Jersey, approximately 50 percent of the households installed the water closet devices and the faucet aerators when the devices were distributed door-to-door. Only 20 percent of the households installed the showerhead devices during the same program (AWWA, 1983).

The East Brunswick program was not undertaken in drought conditions and represents a measure of responsiveness from the public to a retrofit distribution program in a long-term situation. Using these values of public responsiveness and the reductions based on performance of the devices, the effectiveness of retrofit distribution can be determined.

7. Retrofit Distribution and Installation

Effectiveness estimates for this measure are based on the same New Brunswick study mentioned in the previous section. The only difference in effectiveness is that all households will have the devices installed instead of relying on voluntary help of each consumer. The New Brunswick program showed only 10 percent of the devices originally installed were removed due to customer dissatisfaction. Thus, based on these results, 90 percent of all retrofit kits which would be installed under this conservation measure in the Fargo-Moorhead area would remain in use. Thus, a higher level of effectiveness can be attributed to the installation of these kits. The reductions in household water use for each device were the same used for the retrofit distribution and the water-saving fixtures.

8. Sprinkling Ordinances

Sprinkling ordinances can produce substantial reductions in average-day use and maximum day use. A water conservation program in Elmhurst, Illinois, produced water reductions of 5 percent in average day use. Sprinkling ordinances were part of that program, which consisted of education, leak detection, and retrofit devices. In a recent Colorado study on sprinkling restrictions on residential water uses, an average 4-percent reduction in average day water use was reported (AWWA, 1983). The reductions vary depending on the specific type of restrictions and ordinances applied, as well as the existing use. A water conservation program in Pinellas County, Florida, imposed daytime sprinkling restrictions and reduced the maximum day use by 20 percent. Elmhurst, Illinois, reported a 30-percent maximum day use reduction.

Residential seasonal use is commonly the dominant component of municipal seasonal use (particularly in the urban core of the Fargo-Moorhead area); the other sectors have little effect. Therefore, all reductions due to conservation are assumed to come from the residential sector. In this study, a sprinkling ordinance restricting lawn watering to every third day between 8 p.m. and 10 a.m. is estimated to produce a 3- to 5-percent reduction in municipal average-day use, a 14-percent reduction in maximum day use, and up to a 31-percent reduction in seasonal use in study area communities. These levels of water use reductions appear consistent with published results.

9. Education

An education campaign is an integral part of every water conservation program, and education is usually not applied only as a measure in itself. Therefore, it is difficult to determine the impact of this measure alone on the water demand of a community. However, much has been written about this measure, and

it is used extensively to explain the necessity to conserve water. A water conservation program undertaken by the Washington Suburban Sanitary Commission (WSSC) most closely approximated the conditions associated with the sole use of education as a conservation measure. They estimated the reductions in water due to the educational program at 1.7 percent of the average-day use. This educational program was part of a water conservation campaign which included meter maintenance, retrofit distribution, leak detection and system maintenance, and plumbing code modifications, though the educational program was applied alone prior to the implementation of the other measures. Other sources indicate an educational program can have a water savings of up to 5 percent (AWWA, 1983).

Based on the WSSC study, reduction in average day use is estimated to be 2 percent for the Fargo-Moorhead area. The largest reductions would come from the seasonal use of the residential sector due to sprinkling. An educational program would provide consumers with proper techniques of watering effectively and efficiently, reducing wasteful practices for outdoor use. A seasonal use reduction in municipal use of 7 percent is estimated, along with a non-seasonal reduction of 2 percent in the residential sector and a 1-percent reduction in the commercial sector. These effectiveness estimates would produce the overall 2-percent reduction from implementing an educational program.

C. POTENTIAL MEASURES' EFFECT ON PROJECTED WATER USE

Based on the disaggregated forecasts and the reported effectiveness of each potential measure in the preceding sections, the effect of implementing potential water conservation measures can now be determined. The effectiveness or water demand reductions are based on the following relationship:

$$E = Q \times R \times C$$

E = effectiveness of the measure (mgd)
Q = estimated water use in sector (mgd)
R = percent reduction in sector use due to measure implementation
C = coverage of measure (fractional percent of sector)

The estimated water use, Q, is presented in the disaggregated forecasts for each sector of each community. The fractional reduction in water use, R, is the percentage reduction from literature, as described in the preceding section. The last variable is the coverage of the measure, C, which is the area or group in the sector affected by the implemented measure.

For each potential conservation measure, the effectiveness was calculated by sector, by community, and by flow dimension (seasonal use, average-day use, maximum-day use, consumptive use, and average-day sewer contribution) using the above-mentioned equation. These reductions were tabulated and the collective reductions for urban core and rural communities were determined. A summary of these reductions for each potential water conservation measure is shown in Table 9. A range of percentages is presented for water-saving fixtures because the number of households affected increases yearly (thereby increasing coverage, C).

The effectiveness or reduction in millions of gallons per day is presented in Table 10. The demand without water conservation is presented by flow dimension for the urban core and the rural communities first. This is followed by estimates of demands in years 2000 and 2030, assuming implementation of each measure in isolation. The numbers shown in parentheses are the effectiveness estimates, and the numbers above these values are the expected water demands if the conservation measure is implemented. The total effectiveness estimates for each measure is also presented.

These tables provide a clear indication of the relative effectiveness of each of the potential measures. They also show how the effectiveness varies with the flow dimension for some measures. This will become important in Chapters VII and VIII when determining foregone costs associated with implementation of the measure, and ultimately in the eligibility and ranking of the measures.

TABLE 9

AVERAGE PERCENTAGE REDUCTIONS IN WATER USE AND SEWER FLOW
- percent -

	Seasonal Use		Average-Day Use		Maximum-Day Use		Consumptive Use		Average-Day Sewer Contribution	
	Urban Core	Rural	Urban Core	Rural	Urban Core	Rural	Urban Core	Rural	Urban Core	Rural
Metering	--	32	--	9	--	20	--	23	--	--
Meter Maintenance	1	1	1	*	1	*	1	1	1	--
Leak Detection and System Maintenance	--	--	3	--	1	--	7	--	--	--
Pricing	7	7	3	4	9	8	3	4	2	2
Water-Saving Fixtures	--	--	1-2	2-4	1-3	1-2	--	--	1-3	2-5
Retrofit Distribution	--	--	3	5	1	2	--	--	4	6
Retrofit Distribution and Installation	--	--	6	10	3	6	--	--	8	8
Sprinkling Ordinances	31	30	4	5	14	14	11	20	--	--
Education	7	7	2	3	5	5	3	4	1	2

- Not affected.

*Less than 1 percent.

NOTE: Effectiveness is indicated by average municipal values. Due to differing patterns of municipal use, effectiveness values may vary from community to community. A range of values is shown when effectiveness changes occur over the study period.

TABLE 10

EFFECT OF WATER CONSERVATION ON WATER USE AND SEWER FLOWS
- flow in mgd -

Conservation Measure/Communities	Year 2000 Seasonal Use	Year 2000 Average Day Use	Year 2000 Maximum Day Use	Year 2000 Consumptive Use	Year 2000 Average Day Sewer Contribution	Year 2030 Seasonal Use	Year 2030 Average Day Use	Year 2030 Maximum Day Use	Year 2030 Consumptive Use	Year 2030 Average Day Sewer Contribution
Water Demand w/o Conservation										
Urban Core	2.515	20.904	44.628	6.900	16.269	3.056	26.329	56.428	8.641	19.988
Rural	0.072	0.432	0.864	0.109	0.300	0.092	0.590	1.180	0.142	0.393
Total Use	2.587	21.336	45.492	7.009	16.569	3.148	26.919	57.608	8.783	20.381
Metering										
Glyndon	0.024 (0.010)	0.100 (0.010)	0.175 (0.045)	0.035 (0.010)	0.104	0.025 (0.011)	0.107 (0.011)	0.188 (0.048)	0.037 (0.011)	0.110
Sabin	0.015 (0.008)	0.077 (0.008)	0.136 (0.034)	0.024 (0.008)	0.053	0.025 (0.011)	0.1131 (0.011)	0.1975 (0.051)	0.037 (0.011)	0.076
Total Use Total Reduction	0.039 (0.018)	0.177 (0.018)	0.311 (0.079)	0.059 (0.018)	0.157	0.050 (0.022)	0.220 (0.022)	0.385 (0.099)	0.074 (0.022)	0.186
Meter Maintenance										
Urban Core	2.491 (0.024)	20.748 (0.156)	44.259 (0.369)	6.876 (0.024)	16.137 (0.132)	3.027 (0.029)	26.132 (0.197)	55.977 (0.451)	8.612 (0.029)	19.820 (0.168)
Rural	0.071 (0.001)	0.431 (0.001)	0.860 (0.004)	0.108 (0.001)	0.300 (0)	0.091 (0.001)	0.589 (0.001)	1.174 (0.006)	0.141 (0.001)	0.393 (0)
Total Use Total Reduction	2.562 (0.025)	21.179 (0.157)	45.119 (0.373)	6.984 (0.025)	16.437 (0.132)	3.118 (0.030)	26.721 (0.198)	57.151 (0.457)	8.753 (0.030)	20.213 (0.168)

NOTE: Two numbers are presented to describe the effect of the water conservation measure on each dimension of water use. The top number is the use with the particular measure and the parenthetical number is the reduction attributable to the measure.

TABLE 10 (Continued)

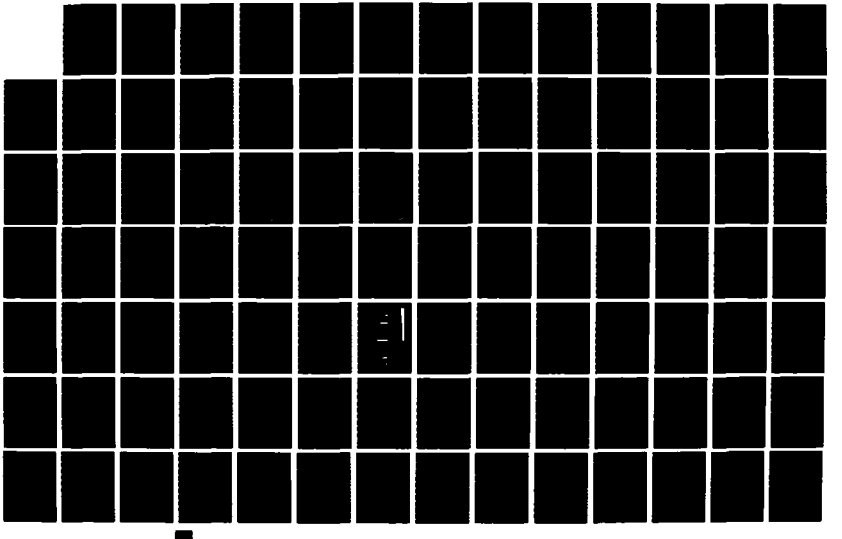
EFFECT OF WATER CONSERVATION ON WATER USE AND SEWER FLOWS
- flow in mgd -

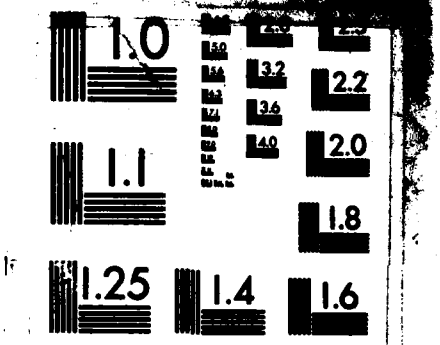
Conservation Measure/Communities	Year 2000 Seasonal Use	Year 2000 Average Day Use	Year 2000 Maximum Day Use	Year 2000 Consumptive Use	Year 2000 Average Day Sewer Contribution	Year 2030 Seasonal Use	Year 2030 Average Day Use	Year 2030 Maximum Day Use	Year 2030 Consumptive Use	Year 2030 Average Day Sewer Contribution
Leak Detection and System Maintenance										
Fargo	1.450	13.162 (0.338)	28.872 (0.338)	4.692 (0.338)	8.780	1.860	16.935 (0.435)	37.145 (0.435)	6.055	11.040
Pricing										
Urban Core	2.325 (0.190)	20.374 (0.530)	40.828 (3.800)	6.710 (0.190)	15.929 (0.340)	2.833 (0.223)	25.666 (0.663)	51.768 (4.660)	8.418 (0.223)	19.548 (0.440)
Rural	0.067 (0.005)	0.414 (0.018)	0.793 (0.071)	0.104 (0.005)	0.288 (0.012)	0.079 (0.006)	0.566 (0.024)	1.085 (0.095)	0.136 (0.006)	0.377 (0.016)
Total Use Total Reduction	2.392 (0.195)	20.788 (0.548)	41.621 (3.871)	6.814 (0.195)	16.217 (0.352)	2.912 (0.229)	26.232 (0.687)	52.853 (4.755)	8.554 (0.229)	19.925 (0.456)
Water-Saving Fixtures										
Urban Core	2.515	20.729 (0.175)	44.453 (0.175)	6.900	16.094 (0.175)	3.056	25.718 (0.611)	55.817 (0.611)	8.641	19.377 (0.611)
Rural	0.072	0.424 (0.008)	0.856 (0.008)	0.109	0.293 (0.007)	0.092	0.564 (0.027)	1.154 (0.027)	0.142	0.373 (0.020)
Total Use Total Reduction	2.587	21.153 (0.183)	45.309 (0.183)	7.009	16.387 (0.182)	3.148	26.282 (0.638)	56.971 (0.638)	8.783	19.750 (0.631)

NOTE: Two numbers are presented to describe the effect of the water conservation measure on each dimension of water use. The top number is the use with the particular measure and the parenthetical number is the reduction attributable to the measure.

AD-A157 286 FARGO-MOORHEAD URBAN STUDY WATER CONSERVATION APPENDIX 2/3
(U) CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT
MAY 85

UNCLASSIFIED F/G 13/2 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TABLE 10 (Continued)

EFFECT OF WATER CONSERVATION ON WATER USE AND SEWER FLOWS
- flow in mgd -

Conservation Measure/Communities	Year 2000 Seasonal Use	Year 2000 Average Day Use	Year 2000 Maximum Day Use	Year 2000 Consumptive Use	Year 2000 Average Day Sewer Contribution	Year 2030 Seasonal Use	Year 2030 Average Day Use	Year 2030 Maximum Day Use	Year 2030 Consumptive Use	Year 2030 Average Day Sewer Contribution
Retrofit Distribution										
Urban Core	2.515	20.291 (0.613)	44.015 (0.613)	6.900	15.656 (0.613)	3.056	25.531 (0.798)	55.630 (0.798)	8.641	19.190 (0.798)
Rural	0.072	0.411 (0.021)	0.843 (0.021)	0.109	0.283 (0.017)	0.092	0.563 (0.027)	1.153 (0.027)	0.142	0.371 (0.022)
Total Use Total Reduction	2.587	20.702 (0.634)	44.858 (0.634)	7.009	15.939 (0.630)	3.148	26.094 (0.825)	56.783 (0.825)	8.783	19.561 (0.820)
Retrofit Distribution and Installation										
Urban Core	2.515	19.596 (1.308)	43.320 (1.308)	6.900	14.961 (1.308)	3.056	24.627 (1.702)	54.726 (1.702)	8.641	18.286 (1.702)
Rural	0.072	0.384 (0.048)	0.816 (0.048)	0.109	0.261 (0.039)	0.092	0.529 (0.061)	1.119 (0.061)	0.142	0.344 (0.049)
Total Use Total Reduction	2.587	19.980 (1.356)	44.136 (1.356)	7.009	15.222 (1.347)	3.148	25.156 (1.763)	55.845 (1.763)	8.783	18.630 (1.751)

NOTE: Two numbers are presented to describe the effect of the water conservation measure on each dimension of water use. The top number is the use with the particular measure and the parenthetical number is the reduction attributable to the measure.

TABLE 10 (Continued)

EFFECT OF WATER CONSERVATION ON WATER USE AND SEWER FLOWS
- flow in mgd -

Conservation Measure/Communities	Year 2000 Seasonal Use	Year 2000 Average Day Use	Year 2000 Maximum Day Use	Year 2000 Consumptive Use	Year 2000 Average Day Sewer Contribution	Year 2030 Seasonal Use	Year 2030 Average Day Use	Year 2030 Maximum Day Use	Year 2030 Consumptive Use	Year 2030 Average Day Sewer Contribution
Sprinkling Ordinances										
Urban Core	1.731 (0.784)	20.120 (0.784)	37.937 (6.691)	6.116 (0.784)	16.269	2.152 (0.904)	25.425 (0.904)	49.491 (6.937)	7.737 (0.904)	19.988
Rural	0.050 (0.022)	0.410 (0.022)	0.723 (0.121)	0.087 (0.022)	0.300	0.065 (0.027)	0.563 (0.027)	1.018 (0.162)	0.115 (0.027)	0.393
Total Use Total Reduction	1.781 (0.806)	20.530 (0.806)	38.680 (6.812)	6.203 (0.806)	16.569	2.217 (0.931)	25.988 (0.931)	50.509 (7.099)	7.852 (0.931)	20.381
Education										
Urban Core	2.325 (0.190)	20.567 (0.337)	42.501 (2.127)	6.710 (0.190)	16.122 (0.147)	2.833 (0.223)	25.914 (0.415)	53.827 (2.601)	8.418 (0.223)	19.796 (0.192)
Rural	0.067 (0.005)	0.420 (0.012)	0.823 (0.041)	0.104 (0.005)	0.295 (0.005)	0.086 (0.006)	0.576 (0.014)	1.124 (0.056)	0.136 (0.006)	0.387 (0.006)
Total Use Total Reduction	2.392 (0.195)	20.987 (0.349)	43.324 (2.168)	6.814 (0.195)	16.417 (0.152)	2.919 (0.229)	26.490 (0.429)	54.951 (2.657)	8.554 (0.229)	20.183 (0.198)

NOTE: Two numbers are presented to describe the effect of the water conservation measure on each dimension of water use. The top number is the use with the particular measure and the parenthetical number is the reduction attributable to the measure.

VII. MEASURE-SPECIFIC EFFECTS

This analysis of measure-specific effects describes the advantages and disadvantages resulting from the implementation of specific long-term water conservation measures. These impacts are directly related to implementation of the measure and can be evaluated without knowledge of the water supply plan or associated facilities. These impacts have economic, environmental, and social aspects. Impacts that are not measure-specific and that require knowledge of the water supply plan are presented in Chapter VIII - Other Effects.

Economic aspects of measure-specific effects are major components of the National Economic Development (NED) account. This account is commonly used in the evaluation of Federal projects. NED is best defined in terms of its primary objective: to realize increases in the nation's productive output. This chapter discusses advantageous and disadvantageous NED effects.

A. ADVANTAGEOUS EFFECTS

Advantageous measure-specific effects include energy savings, other economic effects, and positive environmental and social effects. Environmental and social effects are anticipated to be minimal for individual measures, though the combined effect from all measures would be more significant.

1. Energy Savings

Water conservation can have a measurable effect on energy costs through reductions in heated water. Approximately 15 percent of the total energy used in the residential sector is used to heat water, and over 60 percent of this energy is used for the shower, bath, or lavatory (AWWA, 1981). Thus, a reduction in hot water use could substantially reduce hot water heating costs

for residential and commercial use. Energy cost savings are based on the amount of hot water conserved, the type of water heater used (natural gas or electric), its efficiency, and the cost of its fuel. Between 17 and 28 percent of total water savings is heated water, depending on the conservation measure implemented. Hot water conservation results from utilizing water-saving fixtures (such as dishwashers, washing machines, aerating faucets, and shower heads), and from voluntary reductions in use.

The amount of energy saved depends on the type of the water heaters used and their efficiencies. A market study by the Northern States Power Company (NSP) indicates 40 percent of the households in the area have electric hot water heaters. The remaining hot water heaters are assumed to be gas. Thermal efficiencies for gas and electric hot water heaters are estimated based on a staff report from the Community Conservation Division of the California Energy Resources Conservation and Development Commission entitled, "The California Appliance Efficiency Program," written in November 1977. Average efficiencies for gas and electric hot water heaters were estimated at 79 percent and 98 percent, respectively. These values are reasonable approximate average values for the Fargo-Moorhead area.

Electric and gas rates were obtained from NSP and the Moorhead Public Service Department. Electric rates generally increase with use; however, to simplify the analysis, a more representative weighted average was developed for the entire study area. The estimated electric rate used was 4.3¢ per kilowatt hour. Natural gas prices also vary monthly, but recently averaged 58¢ per 100 cubic feet throughout the year for the study area.

Because the number of installations using alternative sources of energy such as fuel oil was not available, they were assumed to convey energy savings similar to gas hot water heaters.

The foregoing information was used to compute the year 2000 and 2030 energy cost savings for each potential measure. Six of the potential water conservation measures produced significant energy savings and are presented in Table 11. Cost estimates are presented separately for the urban core and the rural communities. The hot water and energy savings are ultimate year 2030 savings expressed as equivalent uniform annual savings for the planning period.

The measure with the greatest annual savings is retrofit distribution and installation. It will save approximately $640,800 in the urban core communities and $25,400 in the rural communities annually. Water-saving fixtures produce large cost savings in the last years of the planning period, but because the early years produce small savings with only new construction being affected, the equivalent annual cost savings are only $79,000 for the urban core communities and $3,300 for the rural communities.

Energy savings, in addition to heated water savings, could be obtained from the private wells serving the communities of Reile's Acres, Prairie Rose, Rustad, and Kragnes. Assuming a combined efficiency for each pump and motor of 64 percent, the sum of the total additional uniform annual cost savings for retrofit distribution and installation in these communities would be $40 per year. The cost savings for each of the other measures would be less than $20 per year.

TABLE 11

ENERGY SAVINGS FOR EACH AFFECTED CONSERVATION MEASURE

Conservation Measure	Urban Core Communities				Rural Communities			
	Hot Water Savings (mgy)	Gas (10^3 ccf/yr)	Electric (10^3 kwh/yr)	Uniform Annual Savings ($/yr)	Hot Water Savings (mgy)	Gas (10^3 ccf/yr)	Electric (10^3 ccf/yr)	Uniform Annual Savings ($/yr)
Meter Maintenance	6.13	31.0	489.0	29,200	--	--	--	--
Pricing	44.97	228.0	3,590.0	210,800	1.81	8.9	140.0	9,900
Water-Saving Fixtures	62.44	316.0	4,980.0	79,000	2.58	12.8	200.0	3,300
Retrofit Distribution	49.52	251.0	3,950.0	182,300	1.70	8.6	135.0	6,100
Retrofit Distribution and Installation	173.94	882.0	13,800.0	640,800	5.93	30.0	470.0	25,400
Education	19.62	99.0	1,570.0	92,500	0.77	3.7	63.0	3,700

NOTE: 40 percent of hot water heaters are electric.

60 percent of hot water heaters are gas.

Estimated thermal efficiencies: Gas - .79; Electric - .98.

Hot water, gas, and electric savings listed are for the year 2030.

2. Additional Economic Effects

Additional economic effects include external economic benefits. External economic benefits are benefits which accrue to external users of the resource as a result of implementation of a specific conservation measure by municipalities. External users of the resource that may be affected include irrigators or other water consumers. Irrigators may benefit economically from greater availability of ground water, primarily in the Buffalo Aquifer, or reaches of the Red River between the Fargo and Moorhead water intakes and outfalls. The increase in available water may also reduce pumping costs. Municipalities and other users downstream may benefit from increases in quality or quantity of available water supplies. Better quality water could reduce treatment costs, and a larger water supply could reduce facility expansion costs. In general, these effects are measure-specific only to the extent the individual measure contributes to the overall impact of all measures applied.

Additional economic benefits of leak detection include decreased leak-related costs, including foregone long-run repair and insurance costs. A detailed study would have to be conducted to quantify these effects. They may be significant for communities with high percentages of unaccounted-for water.

3. Environmental and Social Effects

Measure-specific environmental and social effects are shown in Table 12. Advantageous environmental effects are related to reduced wastewater flows, as well as reduced demands on water resources.

Each water conservation measure reduces demands on water resources. The economic benefits in terms of foregone supply costs are greatest if the reductions attributable to conservation are applied to scale down ground-water development. The alternative would be to credit the reductions to decrease surface water demands. Reductions from individual measures would range from

TABLE 12

POSSIBLE ENVIRONMENTAL AND SOCIAL IMPACTS
OF POTENTIAL WATER CONSERVATION MEASURES

	Environmental Impacts		Social Impacts	
Measure	Advantages	Disadvantages	Advantages	Disadvantages
Metering			Utility revenues may increase.	Costs to meter may be high causing temporary operating deficit. Higher water rates may be necessary to generate funds to cover costs for implementing the program. Political opposition to measure.
Leak Detection	Reduced risk of contaminating water distribution system. Reduced property damage as a result of fewer breaks.		Lower long-run repair costs. Decreased leak-related costs; lower insurance and litigation costs. Measure promotes public cooperation with conservation efforts. Utility revenues may increase.	Cost to implement program. Higher water rates may be necessary to fund program. New personnel may be needed.
Meter Maintenance	Slightly reduced sewer contributions may increase efficiency of on-site wastewater treatment systems due to longer detention times.	Increased wastewater pollutant concentrations from reduced wastewater return flow volumes. (Decreasing return flow volumes and possibly treatment efficiency, hence, increasing impact on aquatic resources below outfalls.) Decreased energy cost to	Utility revenues may increase.	Costs to implement program. May increase water bills for customers with mis-registering meters.

TABLE 12 (continued)

POSSIBLE ENVIRONMENTAL AND SOCIAL IMPACTS
OF POTENTIAL WATER CONSERVATION MEASURES

	Environmental Impacts		Social Impacts	
Measure	Advantages	Disadvantages	Advantages	Disadvantages
Pricing	Reduced sewer contribution may increase efficiency of on-site wastewater treatment systems due to longer detention times.	Large water users may develop own sources (probably ground water, thereby increasing the risk of mining). Increased wastewater pollutant concentrations from reduced wastewater return flow volumes. (Decreasing return flow volume and possibly treatment efficiency, hence, increasing impact on aquatic resources below outfalls.)	Utility revenues may increase. Decreased energy costs to consumer.	Cost to implement measure. Higher water rates may be associated with price level changes. New industry may not be as attracted to community if price levels are raised significantly. Opposition to measure by special interest groups.
Water-Saving Devices (Same impacts are anticipated for all types of water-saving device measures)	Reduced sewer contribution may increase efficiency of on-site wastewater treatment systems due to longer detention times.	Increased wastewater pollutant concentrations from reduced wastewater return flow volumes. (Decreasing return flow volume and possibly treatment efficiency, hence, increasing impact on aquatic resources below outfalls.)	Decreased energy costs to consumer. Decreased consumer water bills.	Cost to implement program. Peer pressure to comply with program. Utility revenues may decrease.

TABLE 12 (continued)

POSSIBLE ENVIRONMENTAL AND SOCIAL IMPACTS
OF POTENTIAL WATER CONSERVATION MEASURES

	Environmental Impacts		Social Impacts	
Measure	Advantages	Disadvantages	Advantages	Disadvantages
Sprinkling Ordinances		Possible damage to lawns and shrubs.	Decreased consumer water bills	Costs to implement ordinance including enforcement efforts. Utility revenues may decrease. Community lifestyle may be slightly altered Special interest group opposition to measure. May affect community development plans. Opposition to measure. Peer pressure to comply with measure.
Education	Slightly reduced sewer contribution may increase efficiency of on-site wastewater treatment systems due to longer detention times.	Increased wastewater pollutant concentrations from reduced wastewater return flow volumes. (Decreasing return flow volume and possibly treatment efficiency; hence, increasing impact on aquatic resources below outfalls.)	Decreased energy costs to consumer. Decreased consumer water bills. Measure provides an understanding of utility operations promoting user and political cooperation with conservation efforts. Measure is well received by users and local government.	Costs to implement measure. Peer pressure to conserve water. Utility revenues may decrease.

0 to 1.7 mgd (0 to 2.6 cfs) if the entire reduction was utilized to reduce surface water withdrawals. This would allow a smaller surface water intake expansion at the Fargo water treatment plant. It would also allow slightly higher in-stream flows reducing the duration of substandard flows, in turn benefiting aquatic resources. The average reductions attributable to the implementation of individual conservation measures offer minimal economic and aquatic resource benefits. The effect of a combination of measures on streamflow is addressed in Chapter X. Other advantageous environmental impacts are attributed to leak detection. Specifically, these provide a reduced risk of contamination to the system and reduced property damages as the result of fewer breaks.

The efficiency of septic systems and stabilization ponds could be increased as a result of conservation. Reduced wastewater flows would facilitate longer detention times and could improve treatment quality. However, these benefits are probably small and could be offset by increased pollutant concentrations in wastewater.

Advantageous social effects are also shown in Table 12. These effects were identified largely from knowledge gathered as part of the social acceptability study reported in Chapters IV and V. Costs associated with these effects are generally unquantifiable.

Three measures, metering, meter maintenance, and pricing, may increase utility revenues and the extra revenue may be used to defray implementation costs. However, the magnitude of any change in utility revenue depends on the exact price levels associated with a particular measure, and these levels cannot be determined without a municipal rate study. Leak detection and education promote community cooperation, understanding of utility operations, and are well received by users and the local government.

B. DISADVANTAGEOUS EFFECTS

Disadvantageous measure-specific effects include implementation costs and environmental and social effects. As with advantageous effects, environmental and social disadvantageous effects are expected to be minimal for individual measures, although the combined effect of all measures may be more significant.

1. Implementation Costs

Implementation costs were estimated for each potential measure described in Chapter V. A brief paragraph on each measure follows. The discussion outlines the proposed implementation plan and the basis for each cost estimate. Table 13 presents a summary of the uniform annual costs for the urban core and rural communities with each potential water conservation measure. The table also indicates who is likely to incur the cost of each program.

Metering costs were estimated by assuming meters would be purchased, installed, and maintained for both Glyndon and Sabin, Minnesota, throughout the planning period. All meters are assumed to have a life of 20 years. Residential meters need calibration or maintenance every 10 years. Commercial meters should be calibrated every two years and the industrial meters checked yearly. Additional costs would be incurred for rate studies, meter readers, and the additional clerical help required to process water billing information. The estimated uniform annual cost of these measures is $9,300.

The meter maintenance program is similar to the maintenance portion of the program just described. It includes replacement of meters every 20 years and periodic inspection and maintenance. Rate studies are not necessary, nor is the additional clerical help. Meter maintenance applies to all communities. Yearly procedures involve the following:

TABLE 13

SUMMARY OF IMPLEMENTATION COSTS
(UNIFORM ANNUAL COST, $)

Conservation Measure	Urban Core				Rural			
	Local Govt. Costs	Utility Costs	Water User Costs	Total Costs	Local Govt. Costs	Utility Costs	Water User Costs	Total Costs
Metering	--	--	--	--	--	9,300	--	9,300
Meter Maintenance	--	232,000	--	232,000	--	14,000	--	14,000
Leak Detection and Repair	--	131,000	--	131,000	--	--	--	--
Pricing	5,800	4,500	--	10,300	200	3,800	--	4,000
Water-Saving Fixtures	6,000	--	20,700	26,700	200	--	700	900
Retrofit Distribution	--	83,100	--	83,100	--	4,000	--	4,000
Retrofit Distribution and Installation	--	142,200	--	142,200	--	6,000	--	6,000
Sprinkling Ordinances	6,800	--	--	6,800	700	--	--	700
Education	21,000	--	--	21,000	2,900	--	--	2,900

1. Replace 5 percent of all residential and commercial meters.
2. Calibrate 10 percent of all residential meters.
3. Calibrate 50 percent of all commercial meters.
4. Calibrate all meters larger than 3 inches.
5. Calibrate master meters.

The uniform annual costs of the meter maintenance program for the urban core and the rural communities are $232,000 and $14,000, respectively.

Leak detection and repair requires the following items in order to operate successfully:

1. Calibrate master meters and meter all water for public use.
2. Locate leaks using a sonic listening device (start with suspect areas of city).
3. Chart leaks to develop history of failures in order to anticipate problem areas.
4. Repair leaks located by program.
5. Evaluate costs as to economics of program.

Implementation cost estimates assume all these tasks are undertaken. The major costs associated with this measure are the labor, equipment, and the repair costs. Labor costs were developed utilizing a full-time crew and necessary supervision to complete work in Fargo in 2 years. A leak detection study performed by the East Bay Municipal Utility District (EBMUD) served as a guide to estimates on production, necessary equipment, and types and number of repairs which can be expected during a study of this nature. The uniform annual costs for implementation of this measure for Fargo is $131,000.

Pricing measures have two components of implementation: a modest education program and a rate study to develop new water rates. The cost of an education campaign consists of expenses for production and distribution of bill inserts, newsletters, pamphlets, and handouts informing the water consumer on the necessity of changing price structures and how it relates to conserving water. A rate study would have to be undertaken to determine any new price levels. The cost of the rate study and the education package would be a one-time cost implemented in 1 year. The uniform annual cost of this measure for the urban core and the rural communities are $10,300 and $4,000, respectively.

The cost of implementing water-saving fixtures differs by State. In North Dakota, the costs were developed assuming local city ordinances would be passed that would require water-saving fixtures in new construction. They also assume an education program similar to the one used for the pricing measure would be required to pass the ordinance. Additional costs would be incurred by the builder or consumer. Similar costs would be borne by Minnesota communities, but economic incentives instead of ordinances would be used (see Chapter V, Economic Incentives). The cost estimates are based on 50 percent of the builders or consumers taking advantage of these incentives. Both implementation programs are explained further in Chapter V. Education costs similar to those for pricing are included for the passing of the tax incentive program. The increased costs to builders or consumers for the water-saving fixtures are also included. The total uniform annual costs for implementing water-saving fixtures as a conservation measure is $26,700 for the urban core communities and $900 for the rural communities.

Retrofit distribution and retrofit distribution and installation are similar. The only difference is the added cost to install the retrofit devices. The devices are distributed as a kit (containing the six items previously described in Chapter V), to residential and commercial establishments. The program is

assumed to be fully implemented after a 5-year period. After the initial distribution, additional kits will remain available at a depot site where they can be picked up. The cost of the kits would be approximately $13 to the local utility plus any additional cost for administration of the program or distribution of the devices. The uniform annual cost of implementing this program with just distribution would be $83,100 for the urban core communities and $4,000 for the rural communities. Installing the kits is a much greater expense. Even though the kits can be installed with minimal training and a few inexpensive tools, the cost of labor increases the cost to $25.25 for each kit. With this additional expense, the uniform annual cost to implement retrofit distribution and installation is $142,200 for the urban core communities and $6,000 for the rural communities.

The cost to implement a sprinkling ordinance is the lowest of all the potential conservation measures. Many communities use ordinances because of the lower cost to implement. An education package consisting of bill inserts, newsletters, pamphlets, and handouts would help provide public support to pass the ordinance. Legal support to draft the ordinance and local political support to conduct the necessary supervision to ensure its passage through the city council are also required. The uniform annual implementation cost of this program would be $6,800 for the urban core communities and $700 for the rural communities.

Implementation costs for education provide for bill inserts, newsletters, pamphlets, and handouts to keep the community aware of the benefits of water conservation. In addition, a person is generally required to supervise the program. This person would work 4 months a year, and his/her duties would include speaking at local affairs, helping to organize school programs, and

developing information for the newsletters. The estimated uniform annual cost of implementing the education program would amount to $21,000 for the urban core communities and $2,900 for the rural communities.

2. Environmental and Social Effects

The disadvantageous environmental impacts are shown in Table 12. These effects are all minor, with the possible exception of smaller return flow volumes. Pollutant concentrations may increase in wastewater influent, and if the wastewater treatment facilities are biologically overloaded, a slight increase may persist in the treated effluent. It is not anticipated that this effect will outweigh the environmental advantages of treatment benefits associated with increased detention time.

Return flows from wastewater treatment plants may decrease as a collective result of water conservation (see Chapter X, Subsection D). In times of drought, return flows may provide a significant portion of streamflow; thus, any reductions in return flow might have important environmental impacts. The water sources for the urban core communities include both surface and ground water. This water is used by the communities and approximately 75 percent is returned to the rivers as treated wastewater.

In a drought, withdrawals from rivers are curtailed to preserve minimum in-stream flow requirements while ground water and storage meet a larger percentage of the demand. Under these circumstances, return flows to the rivers could exceed river withdrawals. Thus, in droughts, return flows serve to augment river flows downstream of treatment plant outfalls. Since Red River flows under severe drought conditions can approach zero flow, return flows from Fargo and Moorhead can be vital to the health of the aquatic resources, and a significant reduction in return flow could have negative environmental impacts.

Disadvantageous effects of sprinkling restrictions, including damage to lawns and shrubs, are not anticipated, assuming reasonable maintenance and care.

Disadvantageous measure-specific social impacts are also shown in Table 12. These effects are primarily related to the costs of implementing the conservation measures. Other social effects can be caused by special interest groups which may oppose specific conservation measures. Certain pricing structures or price levels, if adopted, could be a negative consideration for industries planning on locating in the study area. Marginal cost and increasing unit pricing structures are often unacceptable to large volume users.

VIII. OTHER EFFECTS

This chapter evaluates the impacts of specific water conservation measures on the water supply plan. The implementation of a specific water conservation measure produces reductions in water demand that may affect the scale, timing, or configuration of portions of the water supply plan. Subsequently, certain characteristics of the supply plan may be changed. In this section, impacts of specific measures on long-run and short-run supply costs, opportunity costs, NED benefits, and environmental and social characteristics are considered. The impacts are also part of the NED account that is used in the following chapter to identify eligible measures for the water conservation proposal developed in Chapter X.

A. FOREGONE SUPPLY COSTS

Foregone supply costs are an advantage or benefit of water conservation. The implementation of water conservation measures may reduce water demand enough that the scale, timing, or configuration of water supply facilities of the selected Phase 2 plan (see the Phase 2 report, "Alternate Sources and Treatment/Distribution Systems") may be affected. The associated savings in supply costs are termed foregone supply costs. In this subsection, short-run and long-run cost savings are presented. They indicate a specific potential water conservation measure's relative contribution toward overall foregone supply costs. "Measure-specific" foregone supply costs are a factor in ranking the potential water conservation measures for the water conservation proposal.

Supply costs include pumping, treating, storing, and distributing water to users plus collecting, treating, and disposing of used water. Other less quantifiable costs include changes in quantity or quality of water as a result of water use. Reductions in water use can lower all of these costs.

Estimating foregone water supply costs consists of estimating the annualized savings of each water supply cost component for each water conservation measure. Short-run incremental supply costs include many of those expenditures which are normally categorized operation, maintenance, and repair (O, M, and R) costs. Short-run incremental costs are estimated considering water use reductions during the period of implementation at year 2000 and at year 2030. Interceding year cost savings were estimated by straight line interpolation. All costs were brought back to present value and then annualized in a uniform series.

Long-run incremental supply costs are associated with future capital expenditures for major equipment and facilities. The date for capital outlay without conservation was estimated for each cost component based on existing demands, projected demands, and existing facility capacity. The capital outlays were then converted to an equivalent annual series, as mentioned above. If facilities are required near the end of the planning period, only a proportionate share of construction costs was used in this evaluation (e.g., if a $2 million treatment expansion with a 20-year life is required in year 2020, capital costs of $1 million were used in the evaluation). Long-run incremental cost savings were determined by repeating this process after including the water conservation of one measure. The annualized incremental cost savings is the difference between the two annualized costs.

The costs saved are the incremental costs of water supply (the costs saved by consuming slightly less water). They include short-run costs such as chemicals for treatment and power for pumping, and long-run costs such as savings accrued through revised, postponed, or cancelled capital improvements.

They do not include costs for supervision, engineering, administration, structural maintenance, metering, financing of existing facilities, or other costs inelastic to water demand.

As shown earlier, different conservation measures affect water use in different ways (peak use, average use, seasonal use, consumptive use, etc.). These same dimensions of water use affect supply costs in different ways. Therefore, the critical dimension(s) of each supply cost component were determined and the savings from conservation were calculated independently for each component. For example, chemical costs for water treatment are dependent on total volumes treated (average use) and are relatively unaffected by peak demands. Conversely, future treatment plant expansions are dependent on peak demands. Table 14 presents the supply cost components and their corresponding water use dimension(s).

1. Short-Run Incremental Costs

Short-run incremental costs are those costs that vary with water use regardless of capital equipment. They typically include variable operation, maintenance, and repair costs for water transmission, treatment, distribution, collection, and wastewater treatment facilities. These costs are based on actual chemical, pumping, and maintenance costs from the local water and wastewater utilities to the extent possible. They have been supplemented with published O & M cost curves for similar-type facilities. All costs are presented in January 1984 dollars.

The largest single short-run incremental cost is for chemicals in water treatment. Chemical costs vary with the water quality and type of treatment. Water quality, in turn, varies with water source and, for surface water

TABLE 14

CRITICAL DIMENSIONS OF WATER USE FOR SUPPLY COSTS

	Critical Water Use Dimension			
Short-Run Incremental Costs	Peak Use	Average Use	Seasonal Use	Sewer Contribution
Water Supply				
Chemicals		X		
Power		X		
Equipment Maintenance		X		
Other		X		
Wastewater				
Chemicals				X
Power				X
Equipment Maintenance				X
Other				X
Long-Run Incremental Costs				
Water Supply				
Community Interconnections	X			
Raw Water Pumping/Piping	X			
Treatment Plant Expansion	X			
Well Field Expansion	X	X		
Low-Head Reservoir	X	X	X	
Wastewater				
Treatment Plant Expansion				X

supplies, with time of year and recent hydrologic conditions. To simplify the cost analysis, uniform average chemical costs were assumed for the urban core communities.

Currently, 80 to 85 percent of urban core demands are satisfied by surface water supplies. Under the water supply plan proposed in Phase 2 for year 2030 demands, surface water supplies will continue to provide 80 to 85 percent of urban core demands. Therefore, the chemical costs are assumed to be a weighted average of costs for treating the various supplies at the Fargo and Moorhead water treatment plants. These are estimated at $140 per million gallons (mg).

Pumping costs also vary directly with water use, source, treatment facilities, size of the distribution system, and system operating pressures. Average costs per million gallons were computed based on the existing and future mix of supplies and treatment facilities as they were for chemical costs. These are estimated at $60 per mg.

Equipment maintenance and other maintenance costs are assumed to be independent of water use. Most of these maintenance costs will be required regardless of equipment use. The small percentage that may be water use-dependent is insignificant to the results of this study.

The chemical, pumping, and equipment maintenance costs above are for water supply, treatment, and distribution. These costs vary directly with variations in average demand. Similar costs also exist for wastewater collection, treatment, and disposal. These costs vary with sewer contributions. The cost estimates for wastewater collection, treatment, and disposal were computed in a similar manner using existing local data when available and published data as a supplement. Table 15 presents a summary of the incremental costs for the urban core communities.

TABLE 15

INCREMENTAL COSTS - URBAN CORE COMMUNITIES

Cost Component	Incremental Cost	Water-Use Dimension(s)
SHORT-RUN		
Chemicals (Water Treatment)	$ 140/mg	Average Use
Power (Water Supply, Treatment, and Distribution)	$ 60/mg	Average Use
Power (Wastewater Collection, Treatment, and Disposal)	$ 75/mg	Average Sewer Contribution
LONG RUN		
Fargo Water Treatment Plant Expansion	$340,000/mgd	Peak Use
Moorhead Water Treatment Plant Expansion	$280,000/mgd	Peak Use
Buffalo Aquifer Well field	$700,000/mgd	Peak Use/Average Use
Low-Head Dam	$150/ac-ft	Peak Use/Average Use
West Fargo/Fargo Connection	$58,000/mgd	Peak Use at West Fargo
Fargo Wastewater Treatment Plant Expansion	$380,000/mgd	Average Sewer Contribution
West Fargo Wastewater Treatment Plant Expansion	$345,000/mgd	Average Sewer Contribution

Short-run incremental costs also exist for the rural communities, although they differ because these water and wastewater facilities typically have lower O, M, and R costs. Wastewater is treated by either private on-site systems or municipal stabilization ponds. Variable O, M, and R costs for these facilities are negligible.

Smaller communities, if they have water treatment facilities at all, generally only filter and disinfect. As a result, chemical costs are relatively insignificant, and power for pumping becomes the largest component of short-run incremental costs. For the purposes of this evaluation, short-run incremental costs are estimated at $50/mg for the rural communities.

Besides the short-run incremental costs, those communities purchasing water from the CRWUA may save additional money through conservation. At approximately $5.50/1,000 gallons (or $5,500/mg), large savings can be realized on the local level by municipal and individual consumers who conserve.

However, only a portion of these benefits can be viewed as short-run incremental savings, because other costs are included in the price of water, such as allowances for capital costs, fixed operation and maintenance costs, and profit. Therefore, NED savings would not be commensurate with these local savings. Rather, they are assumed to be approximately $50/mg, as assumed for the other rural communities.

2. Long-Run Incremental Costs

Long-run incremental costs are those that vary with the capacity of the water supply facilities. Reductions in water use throughout the planning period may permit planned facilities to be reduced in size, postponed, or eliminated altogether. The resulting change in capital costs (on an annualized basis) is taken to be the foregone long-run cost.

Construction costs are based on EPA cost curves, published unit cost data, manufacturer and supplier information, and recent bid experience on similar projects. They include such items as earthwork, concrete, river diversion, piling, pipelines, pumps, well construction, purchase and installation of equipment, electrical work, site work, contractor's overhead and profit, engineering, legal and fiscal services, and administration. All costs are presented in January 1984 dollars.

Major long-term costs for the urban core communities include water treatment plant (WTP) and wastewater treatment plant (WWTP) expansions, well field development, low-head dam construction, pumping facilities, and piping facilities. The water use dimensions which determine the timing and size of needed construction were previously shown in Table 14.

Construction of new facilities takes place when demands exceed existing capacities; at this point, a treatment plant expansion is undertaken, a new well field is developed, or a low-head dam is constructed. These improvements require a relatively large influx of capital in a short time period, resulting in long-run incremental cost curves that tend to be more step-like than short-run costs over the relevant range of demands. Construction costs were, therefore, computed over a range of expansion capacities and a series of cost curves were developed for the proposed construction. With this family of curves, the relationship between foregone construction costs and water use reductions can be more accurately shown.

The timing of the capital outlays for construction is also an important factor in determining the long-run incremental costs. The effect of timing can be

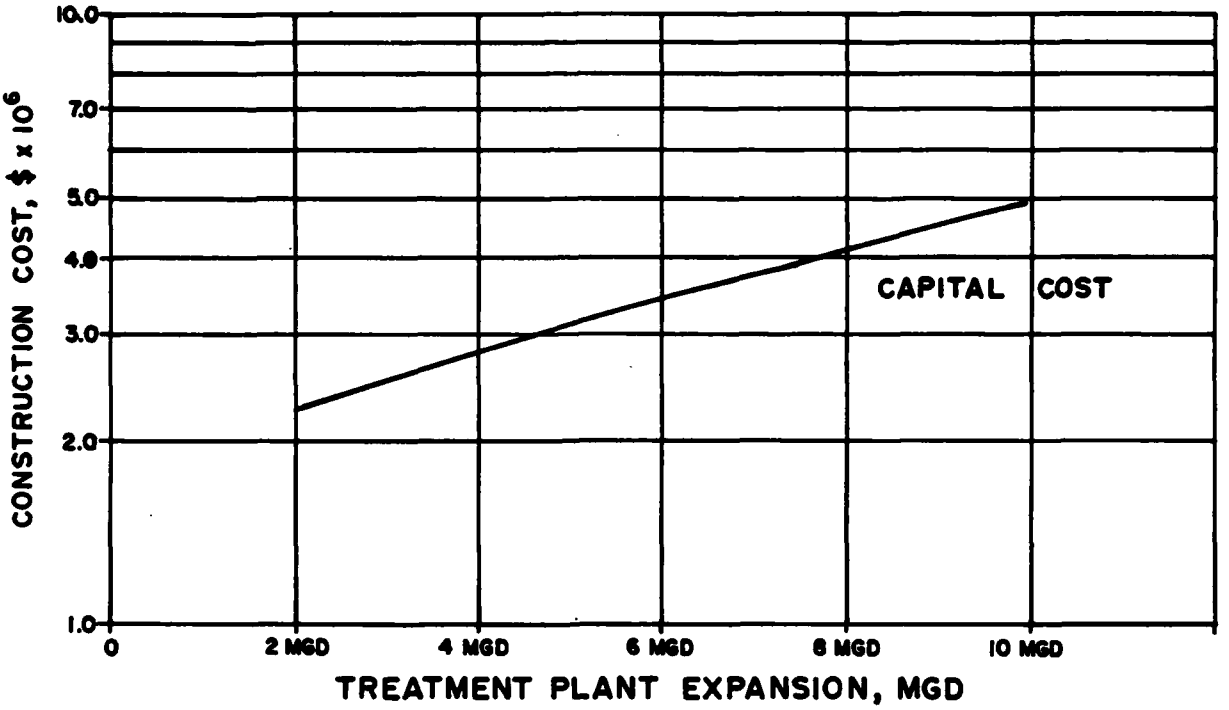
determined by projecting water use (in the relevant dimensions) on a time line. New facilities will need to be constructed when the projected use exceeds available capacity; the size of the needed facilities must be sufficient to meet projected demands in the design year (e.g., 20 years hence for treatment facilities). In this manner, reductions in facility size and postponement in construction can be estimated as water use is reduced. The anticipated impact on annualized costs can then be determined.

Water treatment plant (WTP) expansions must be provided to meet peak demands. This analysis assumes that the Moorhead plant will be expanded primarily to treat new ground-water sources developed and that the Fargo plant will be expanded to treat remaining new demands using the Red and Sheyenne Rivers as primary sources.

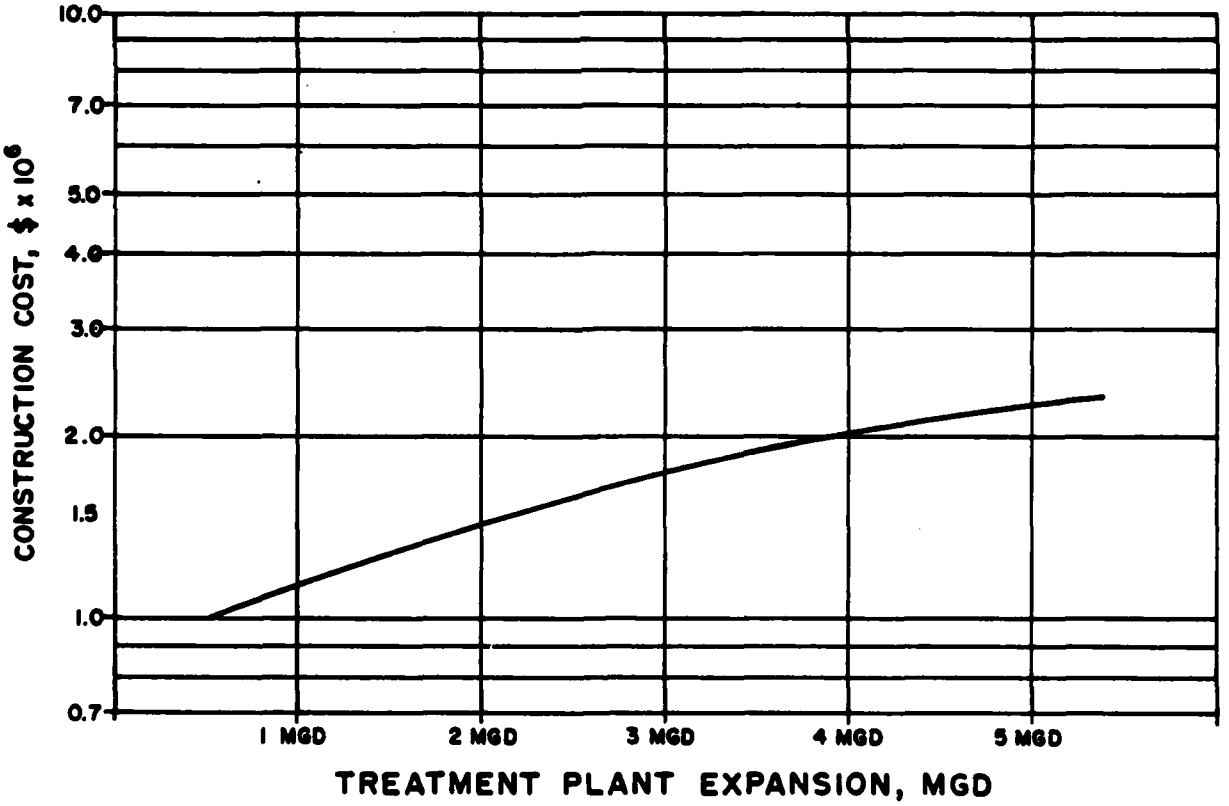
The Moorhead plant expansions would be affected first by water use reductions. This plant would be affected first because, when well field and O, M, and R costs are included, ground-water sources have a higher marginal cost of supply and would be the first sources curtailed. Treatment plant expansion costs are presented in Figure 2. The cost savings depend on actual flow reductions, but marginal savings would average approximately $280,000/mgd at Moorhead and $340,000/mgd at Fargo. Present value costs, annualized costs, and cost per million gallons would depend on the actual cost savings and the timing of construction. This issue will be discussed later when the conservation measures are integrated into the water supply plan.

Wastewater treatment plant (WWTP) expansions must be provided when average annual sewer flows exceed average annual design flows. The treatment facilities can generally accommodate twice the average annual design flows during peak

FARGO WATER TREATMENT PLANT EXPANSION COSTS



MOORHEAD WATER TREATMENT PLANT EXPANSION COSTS



FARGO-MOORHEAD URBAN STUDY WATER TREATMENT PLANT EXPANSION COSTS	E.A. HICKOK & ASSOCIATES HYDROLOGISTS-ENGINEERS MINNEAPOLIS-MINNESOTA	fig. 2

periods. This analysis assumes the Fargo plant would be expanded to treat Fargo's future wastewater loads, and the West Fargo plant would be expanded to meet its own future needs as well as those of Riverside. Moorhead currently has treatment capacity to meet its projected needs as well as those of Dilworth. Therefore, water conservation would create no long-run wastewater treatment cost savings for Moorhead and Dilworth. Treatment plant expansion costs for the Fargo and West Fargo wastewater treatment plants are shown in Figure 3. The cost savings depend on actual flow reductions, but would average approximately $380,000/mgd at Fargo and $345,000/mgd at West Fargo.

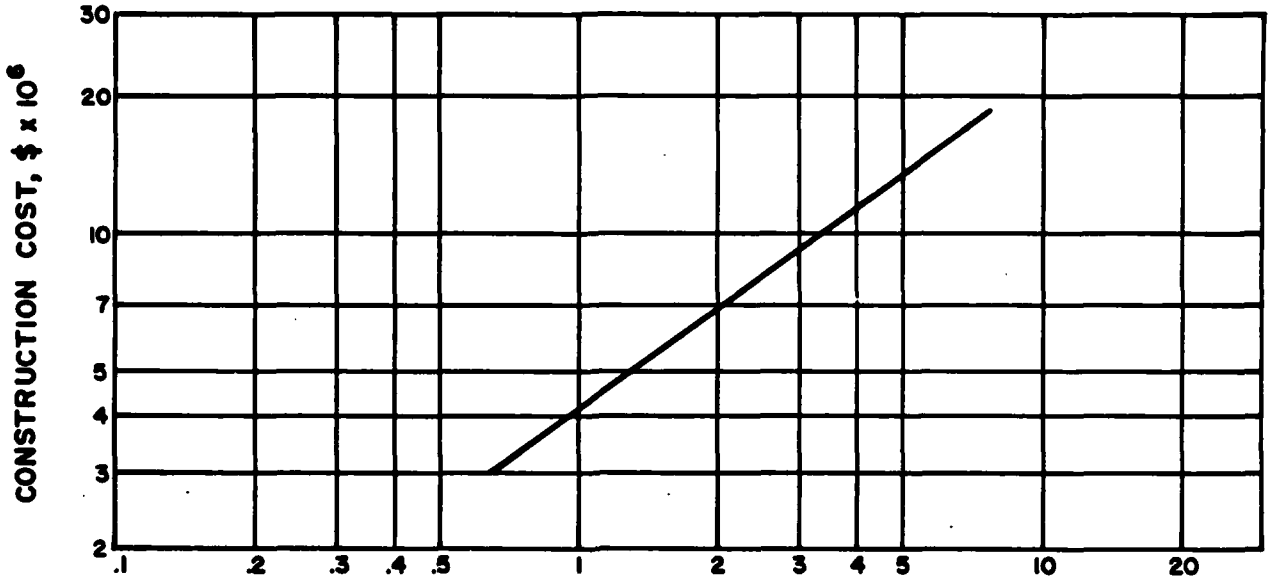
Well field development depends on a combination of average use and peak use dimensions, although it is weighted more toward average use if a storage reservoir is available to accommodate peaks. The raw water pumping station and pipeline serving the well field depends on peak withdrawals from the well field.

Capital costs, shown in Figure 4, are for full development of the Buffalo Aquifer. If well field expansion is phased, the major portion of the cost would occur when the pipeline is constructed. Other expansion would require only additional wells and feeder pipelines.

Capital costs for Buffalo Aquifer well field expansion average approximately $700,000/mgd pumping capacity. The costs would not be linear, but may be approximated by the curve shown in Figure 4. Cost savings occur when flows are reduced to a point that a smaller pipeline can be used or a well and feeder pipeline can be eliminated.

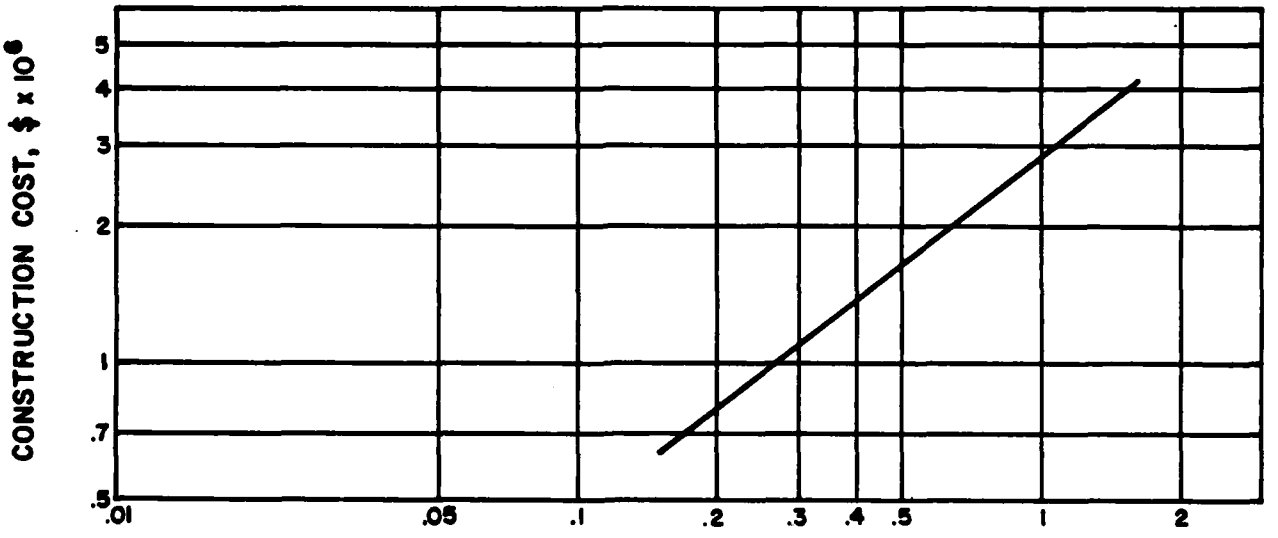
Cost curves for other aquifer expansions are not included because it is not reasonable to expect enough water conservation to alter these expansion plans.

FARGO WASTEWATER TREATMENT PLANT COSTS



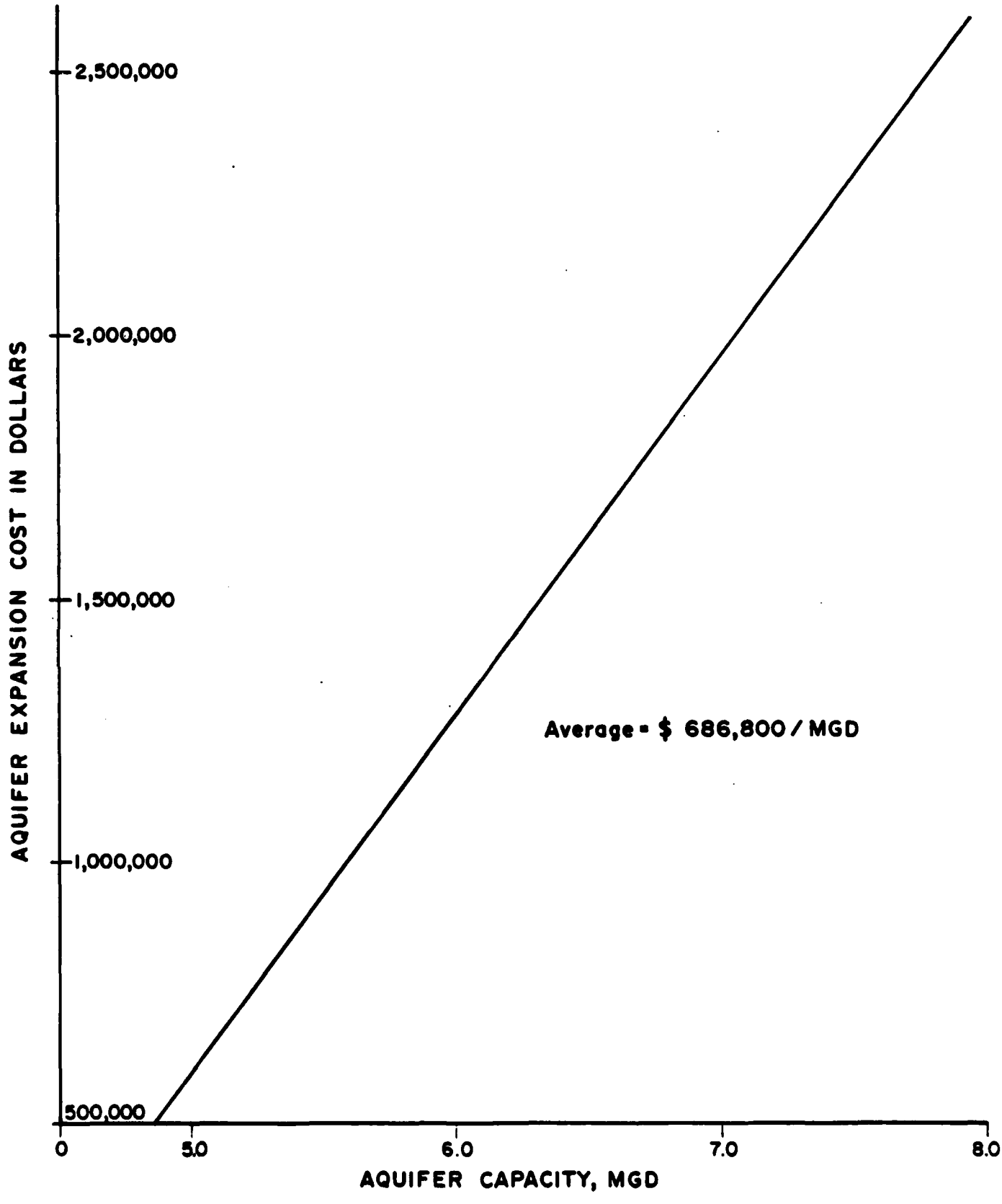
TREATMENT PLANT EXPANSION, MGD

WEST FARGO WASTEWATER TREATMENT PLANT COSTS



TREATMENT PLANT EXPANSION, MGD

FARGO-MOORHEAD URBAN STUDY WASTEWATER TREATMENT PLANT EXPANSION COSTS	E.A. HICKOK & ASSOCIATES HYDROLOGISTS-ENGINEERS MINNEAPOLIS-MINNESOTA	fig. 3



FARGO-MOORHEAD URBAN STUDY	E.A. HICKOK & ASSOCIATES HYDROLOGISTS-ENGINEERS MINNEAPOLIS-MINNESOTA	
BUFFALO AQUIFER EXPANSION		fig. 4

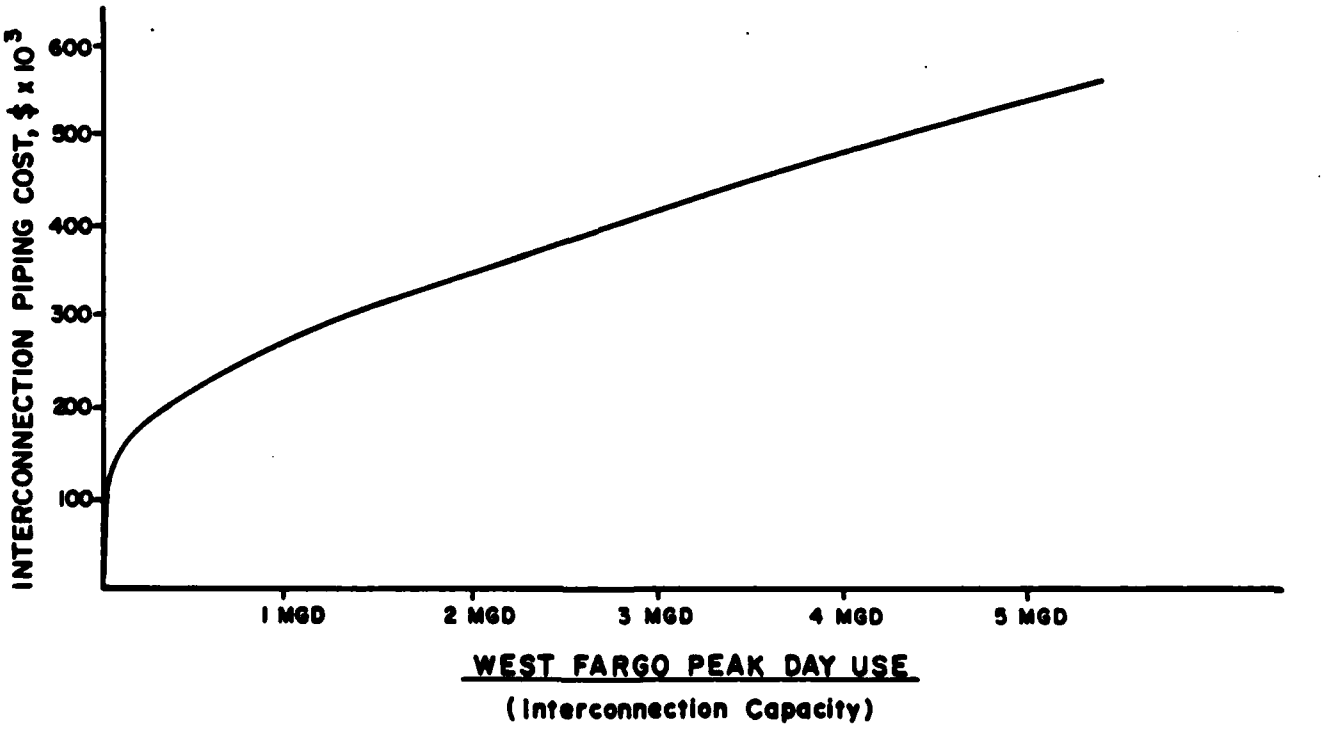
Like well field expansion, replacement of the existing low-head dam with a larger one depends on a combination of average use and peak use. As shown in Figure 5, the capital costs of a low-head dam are relatively insensitive to size. They average approximately $150/acre-foot of additional storage. The major portion of capital costs for in-stream storage are the fixed costs associated with dam construction such as river diversion and existing dam demolition. These costs are estimated at more than $2,500,000. These latter savings can be realized only if sufficient conservation exists to eliminate the need for the low-head dam entirely.

Sizing raw water pumping and piping facilities depends on peak use. Costs for raw water pumping are included with treatment plant costs on Figure 2. Costs for Moorhead piping were included in well field expansion cost in Figure 4. Costs for a pipeline from the Red River to the Fargo water treatment plant are not a significant portion of overall water supply plan costs and have not been included in this analysis.

The size of treated water pumping and distribution facilities also depends on peak use. These facilities are included in treatment plant costs (see Figure 2). Costs for distribution piping and treated water storage within the individual communities are not dependent on future water use reductions. Only costs for the Fargo-West Fargo interconnection will be significantly affected by water use reductions. These savings, as shown in Figure 5, average $58,000/mgd reduction in West Fargo peak day rates. Savings for the Moorhead-Dilworth connection are negligible, and the size of the Fargo-Moorhead connection pipe is independent of future water use reductions. The size of the Fargo-Moorhead connection is, instead, limited by the maximum rate of supply required to be transferred in very severe droughts.

IN-STREAM RESERVOIR CONSTRUCTION COSTS

FARGO/WEST FARGO INTERCONNECTION



FARGO-MOORHEAD URBAN STUDY	E.A. HICKOK & ASSOCIATES	
STORAGE AND PIPING EXPANSION COSTS	HYDROLOGISTS-ENGINEERS MINNEAPOLIS-MINNESOTA	fig. 5

With the exception of possible delays in stabilization pond expansions, none of the capital costs proposed for the smaller communities are dependent on future water use reductions. Recommended water supply facilities are required primarily to meet fire demands with the largest well out of service. The fire flow demands are large enough that any conservation reductions would have a relatively small effect on the scale or timing of these facilities. Therefore, these facilities will be needed regardless of the future water use reductions obtained.

Table 15 also presents each long-term foregone supply cost component, its critical water use dimension, and its estimated incremental cost. Tables 16 and 17 present a summary of the annual foregone water supply costs for each potential measure in the urban core and rural communities, respectively.

B. FOREGONE EXTERNAL OPPORTUNITY COSTS

Foregone external opportunity costs are an advantage or benefit of conservation. Opportunity costs are defined as the value of the benefits not received as a result of committing resources to carry out the designed water supply plan. A water conservation measure that reduces the scale, timing, or configuration of the water supply plan may also reduce associated opportunity costs. This reduction in opportunity cost is termed a foregone opportunity cost. When these benefits are experienced by persons other than those the plan was specifically designed to serve, they are referred to as foregone external opportunity costs.

The main impact of conservation on the water supply plan would be reductions in scale of development in the designated water supply plan (Alternative VI (SRR)). This plan is described in detail in the report, "Water Supply/Conservation Investigations for the Fargo-Moorhead Area: Phase 2." A summary of this plan is included in Chapter XI of this document.

TABLE 16

SUMMARY OF FOREGONE SUPPLY COSTS - URBAN CORE COMMUNITIES

Cost Component	Potential Water Conservation Measure: Meter Maintenance	Leak Detection System Maintenance	Pricing	Water-Saving Fixtures	Retrofit Distribution	Retrofit Distribution and Installation	Sprinkling Ordinances	Education
Short-Run Incremental Costs								
Chemicals (WTP)	$ 5,700/yr	$12,500/yr	$19,700/yr	$ 5,900/yr	$ 22,900/yr	$ 48,900/yr	$ 28,900/yr	$12,500/yr
Power (WTP, supply distribution)	2,500	5,300	8,400	2,500	9,800	21,000	12,400	5,400
Power (WWTP)	2,200	--	5,800	2,300	10,500	22,100	--	2,700
Long-Run Incremental Costs								
WTP Expansion	3,300	5,400	51,700	4,000	9,700	22,100	69,400	33,800
Aquifer Expansion	3,600	5,800	8,700	4,600	10,000	19,600	11,800	5,700
Low-Head Dam Expansion	2,300	3,800	5,300	4,600	6,100	8,600	6,600	3,600
Interconnections(1)	100	--	2,900	700	500	1,200	4,900	1,600
WWTP Expansions(2)	16,200	--	55,500	71,100	103,100	188,100	--	18,700
Total Annual Savings	$35,900	$32,800	$158,000	$95,700	$172,600	$331,600	$134,000	$84,000

(1)West Fargo only.

(2)Fargo and West Fargo only.

NOTE: (WTP) denotes water treatment plant and (WWTP) denotes wastewater treatment plant.

TABLE 17

SUMMARY OF FOREGONE SUPPLY COSTS - RURAL COMMUNITIES

	Metering	Meter Maintenance	Pricing	Water-Saving Devices	Retrofit Distribution	Retrofit Distribution and Installation	Sprinkling Ordinances	Education
Long-Run Incremental Costs								
- WWTP Expansion	$ 0	$ 0	$ 900/yr	$ 600/yr	$1,400/yr	$ 3,500/yr	$ 0	$ 300/yr
Short-Run Incremental Costs								
- Chemicals and Power	200	0	200	100	200	500	200	100
Total Annual Savings	$200	$ 0	$1,100	$ 700	$1,600	$ 4,000	$ 200	$ 400
CRWUA Purchases	0	0	0	$3,900	$6,200	$14,100	$2,600	$2,400

NOTE: WWTP denotes wastewater treatment plant.

The external beneficiaries affected by these changes in the water supply plan depend upon the type of planned facilities that are affected. Well fields and transmission facilities are the first facilities that would be reduced. Therefore, other ground-water users external to the urban core system would benefit from a greater availability of ground water, primarily in the Buffalo Aquifer. These users could include homeowners and irrigators who may have reduced pumping costs and a greater amount of usable water.

Usage patterns of irrigators are not well documented, so it is difficult to quantify the benefits to these external users. The amounts they appropriate each year are highly variable, and the extensive areas of heavy soils limit the amount of land suitable for irrigation.

C. FOREGONE NED BENEFITS

Where the water supply plan includes multi-purpose facilities designed to optimize NED benefits, alterations in the scale, configuration, or timing of the water supply portion may reduce net benefits obtained from other purposes. No such facilities are included in the water supply plan; therefore, this benefit is not assessed.

D. IMPACT ON NEGATIVE ENVIRONMENTAL AND SOCIAL EFFECTS

Negative environmental and social effects of the water supply plan were identified in the Phase 2 report. Reduced water demands resulting from the implementation of specific water conservation measures may mitigate these effects.

The main negative environmental impact associated with full development of the water supply plan is reduced streamflows. This impact is partially mitigated by return flows from wastewater treatment plants. Conservation measures that affect consumptive uses like water sprinkling would reduce municipal demands

on rivers and not reduce municipal return flows. These measures mitigate negative environmental effects and offer more benefits than measures that affect non-consumptive uses. The latter measures reduce municipal demands on rivers, but also reduce return flows by a comparable volume. Therefore, sprinkling ordinances, pricing, education, and meter maintenance mitigate negative environmental effects.

In some plans, the relaibility of supply may be decreased by the incorporation of water conservation measures into the supply plan. This is because the long-term conservation measures integrated into a water supply plan are no longer available as contingent measures to extend the water supply capability during severe droughts. (Contingent measures are conservation efforts implemented for short periods of time during severe water shortages as part of the drought emergency plan.) In this study, the water supply plan is capable of meeting the 50-year drought with or without conservation. In addition, our process of selecting contingent measures addresses this issue and ensures reliability while extending the capability of the water supply/conservation plan through the 100-year event. This process is discussed in detail in Chapter XI.

IX. SUMMARY OF WATER CONSERVATION MEASURE EVALUATION

This section summarizes the important effects associated with the water conservation measures described in detail in the two previous chapters. Quantifiable advantageous National Economic Development (NED) effects include energy savings and foregone supply costs. Implementation costs are quantified as disadvantageous NED effects. Environmental and social effects of specific water conservation measures appear minimal. However, the combined effect of several conservation measures could produce significant environmental and social effects. The economic evaluation does not include non-monetary considerations (both positive and negative), such as drier lawns, increased public costs, improved fishery (because of fewer problems with substandard flows), sewage treatment plant odors, etc., that may influence implementation decisions regarding various conservation measures.

Table 18 summarizes potential measures evaluated for the urban core communities. Two measures show negative net NED effects, leak detection, and meter maintenance. Though the net effect for leak detection does not consider the benefits realized from foregone long-run repair and insurance costs, it is not likely that these benefits could produce a positive net effect. In addition, it is likely that water rates would need to be raised to fund this program if a municipal subsidy or other source of funding were not available.

Environmental and social effects include reduced wastewater return flow volumes and increased water rates. Reduced wastewater return flows are potentially significant environmental impacts, because return flows are a major component of streamflows during drought. Increased water rates are important social impacts because they could be a negative consideration for potential area industries. Price increases may also become a source of social and political controversy if they are felt to be inequitable, unwarranted, or not clearly explained.

TABLE 18

SUMMARY EVALUATION OF WATER CONSERVATION MEASURES - URBAN CORE COMMUNITIES

NED EFFECT (1984 DOLLARS)(1)	Metering	Meter Maintenance	Pricing	Water-Saving Fixtures	Retrofit Distribution	Retrofit Distribution and Installation	Sprinkling Ordinances	Education
Economic Advantages (Benefits)								
Energy Savings	--	29,200	210,800	79,000	182,300	640,800	--	92,500
Additional Economic Effects	A	--	--	--	--	--	--	--
Foregone Supply Costs	32,800	35,900	158,000	95,700	172,600	331,600	134,000	84,000
Total NED Advantages	32,800	65,100	368,800	174,700	354,900	972,400	134,000	176,500
Economic Disadvantages (Costs)								
Implementation Costs	131,000	232,000	10,300	26,700	83,100	142,200	6,800	21,000
Total NED Disadvantages	131,000	232,000	10,300	26,700	83,100	142,200	6,800	21,000
Net Economic Effect	(98,200)	(166,900)	318,500	148,000	271,800	830,200	127,200	155,500
Benefit/Cost Ratio	0.25	0.28	31.92	6.54	4.27	6.84	19.71	8.40
POTENTIALLY SIGNIFICANT ENVIRONMENTAL AND SOCIAL IMPACTS								
Advantageous								
Disadvantageous	C	B	B,C	B	B	B		B

All values are uniform annual dollars for the 50-year study period.

NOTE: ( ) indicates negative quantity.
A - Lower long-run repair and insurance costs for municipal distribution system (unquantifiable).
B - Reduced wastewater return flow volumes.
C - Increased water rates.

(1)Does not include non-monetary factors such as drier lawns, more streamflow, increased costs, improved fishery, etc., that may influence implementation decisions.

Table 19 summarizes potential measures evaluated for the rural communities. Metering, sprinkling ordinances, and meter maintenance have negative net NED effects. Foregone supply costs are relatively low because most future water supply facilities for rural communities are required to meet peak day fire demands, and because reductions caused by conservation have a relatively small effect on the scale or timing of these facilities.

Municipal and individual consumers who contract with the CRWUA for water stand to benefit from reduced water bills if they conserve. The cost of CRWUA water is approximately $5.50/1,000 gallons. However, only a portion of this amount is truly an NED savings because other costs are included in the CRWUA price. The additional benefits in excess of NED savings which would accrue to CRWUA customers as a result of conservation are also included in Table 19.

The only environmental or social impact found to be significant for rural communities was increased water rates. Though conservation measures collectively could significantly reduce the percent of return flows, the absolute amount is not significant relative to streamflows during drought.

TABLE 19

SUMMARY EVALUATION OF WATER CONSERVATION MEASURES - RURAL COMMUNITIES

NED EFFECT (1984 DOLLARS)(1)	Metering	Meter Maintenance	Pricing	Water-Saving Fixtures	Retrofit Distribution	Retrofit Distribution and Installation	Sprinkling Ordinances	Education
Economic Disadvantages (Costs)								
Implementation Costs	9,300	14,000	4,000	900	4,000	6,000	700	2,900
Total NED Disadvantages	9,300	14,000	4,000	900	4,000	6,000	700	2,900
Economic Advantages (Benefits)								
Energy Savings	0	0	9,900	3,300	6,100	25,400	100	3,700
Foregone Supply Costs	200	0	1,100	700	1,600	4,000	200	400
Total NED Advantages	200	0	11,000	4,000	7,700	29,400	300	4,100
Net NED Effect	(9,100)	(14,000)	7,000	3,100	3,700	23,400	(400)	1,200
Benefit/Cost Ratio	0.02	0	2.75	4.44	1.93	4.90	0.43	1.41
Additional Advantages to CRWUA Customers	0	0	0	3,900	6,200	14,100	2,600	2,400
Total NED Advantages (CRWUA)	200	0	11,000	7,900	13,900	43,500	2,900	6,500
POTENTIALLY SIGNIFICANT ENVIRONMENTAL AND SOCIAL IMPACTS								
Advantageous								
Disadvantageous	A		A					B

A - Increased water rates.
B - Reduced wastewater return flow volumes.
( ) indicates negative quantity.

NOTE: All values are uniform annual dollars for the 50-year study period.

(1)Does not include non-monetary factors such as drier lawns, more streamflow, increased costs, improved fishery, etc., that may influence implementation decisions.

X. WATER CONSERVATION PROPOSALS

A. GENERAL

In this section, water conservation proposals are developed for urban core and rural communities. Eligible measures are combined to form a series of trial proposals. These trial proposals are evaluated against each other to select the proposal with the greatest beneficial NED effect. The selected proposal is then integrated into the Phase 2 water supply plan to form a water supply/conservation plan for the Fargo-Moorhead study area. The effects of this integration are discussed in detail in the following chapter.

Table 20 displays two groups of water conservation measures eligible for inclusion in trial proposals for either the urban core or the rural communities. Measures within these groups are ranked according to amount of beneficial NED effects they are anticipated to produce, based on the analyses described in Chapter IX. Relative environmental or social impacts are not included in this stage of the proposed development process.

In this section, eligible measures are combined, one at a time beginning with the measure offering the greatest benefits, to form a series of trial proposals. The effectiveness of each trial proposal is then determined by comparing advantageous and disadvantageous effects. The quantifiable effects include implementation costs, energy savings, and foregone supply costs.

The proposals that result in the greatest beneficial net NED effects for the urban core communities and the rural communities are integrated into the Phase 2 water supply plan. Effects described include economic advantages and disadvantages, aggregate effectiveness, and environmental and social impacts.

TABLE 20

NED MERIT ORDER RANKING OF MEASURES
ELIGIBLE FOR WATER CONSERVATION PROPOSALS

Measure	Net NED Benefits (1984 Dollars)
URBAN CORE COMMUNITIES	
Retrofit Distribution and Installation	$830,200
Pricing	318,500
Retrofit Distribution	271,800
Education	155,500
Water-Saving Fixtures	148,000
Sprinkling Ordinances	127,200
RURAL COMMUNITIES	
Retrofit Distribution and Installation	23,400
Pricing	7,000
Retrofit Distribution	3,700
Water-Saving Fixtures	3,100
Education	1,200

NOTE: All values are uniform annual dollars for the 50-year study period.

This subsection outlines different trial proposals for the urban core and rural communities. Interaction factors which may reduce the combined effectiveness of the measures within the trial proposals are identified and utilized. Measures that are subsequently identified to have a net negative NED effect are dropped from further consideration. A detailed tabulation of the results of the examination of the trial proposals for the urban core is presented in Table 21 following the discussion.

B. PROPOSAL FOR URBAN CORE COMMUNITIES

1. First Trial

In the first trial proposal, retrofit distribution and installation is the only measure included. The effects shown in Table 21 are essentially the same as those described for this measure in previous chapters. This trial proposal produces reductions in the year 2030 average day use of 1.702 mgd and has a beneficial net NED effect of $829,000 per year when combined with the Phase 2 water supply plan.

2. Second Trial

The second trial proposal consists of retrofit distribution and installation plus the next-best measure, a selected peak demand pricing structure compatible with each community's existing rate structure. No interactions that would reduce the additional effectiveness of the pricing measure are anticipated. The combined effectiveness is 2.365 mgd in year 2030 and the beneficial net NED effect ($1,144,700 in annualized savings) is approximately $300,000 greater than Trial Proposal 1.

3. Third Trial

The third trial proposal consists of all measures in the previous proposal plus the next best measure, retrofit distribution. A 100-percent interaction between this measure and the first measure, retrofit distribution and

installation, is anticipated; both measures involve the same distribution, but more people are assumed to install the devices if it is done for them at no charge.

No additional effectiveness or cost would be realized by including retrofit distribution in the final proposal. Therefore, to include retrofit distribution would be redundant and this measure is not included in subsequent proposals.

4. Fourth Trial

The fourth trial proposal includes the retrofit distribution and installation and pricing measures from the second trial proposal plus the education measure. The effectiveness of the educational conservation measure is affected by interactions with the retrofit distribution and installation measure. The retrofit measure includes distribution of a booklet of water-saving tips and media publicity regarding conservation, both components of a purely educational water conservation measure. However, remaining components such as billing inserts and other media programs still offer a means of producing additional reductions.

Thus, interactions with the retrofit distribution and installation measure affect the implementation costs and reduce the additional effectiveness of the educational measure. Implementation costs have been reduced to account for the educational materials already distributed under the retrofit distribution and installation measure. The effectiveness of this measure has also been reduced by approximately 20 percent according to estimations of interactive effects in Algorithm for Determining the Effectiveness of Water Conservation Measures (Richards and others, 1984).

This proposal offers reductions in year 2030 average day use of approximately 2.692 mgd (0.327 mgd more than Trial Proposal 2). It also provides additional net NED advantages of approximately $90,000 per year over Trial Proposal 2, or a total net economic effect of $1,233,600.

5. Fifth Trial

The fifth trial proposal includes all measures of the fourth trial proposal plus the water-saving fixtures measure. The effectiveness of the water-saving fixtures measure is reduced by 90 percent due to interactions with the retrofit measure. The water-saving fixture measure only affects new construction, but the retrofit measure already includes the effects of retrofitting regular fixtures in these buildings. Therefore, the additional effectiveness of using water-conserving fixtures is limited.

Though there is a slight increase in year 2030 average day effectiveness to 2.753 mgd, the net economic effect, $1,228,800, is $4,800 less. Thus, the water-saving fixtures measure is not included in subsequent trial proposals.

6. Sixth Trial

The sixth trial proposal consists of those measures in the fourth proposal (retrofit distribution and installation, peak demand pricing, and education) plus a sprinkling ordinance. The sprinkling ordinance focuses on irrigation, the prime component of seasonal use. Therefore, there is an interaction between the effectiveness of this measure and the pricing and education measures already incorporated into the proposal. The cost of implementing sprinkling ordinances is unaffected by previous measures; however, the effectiveness of these ordinances is estimated to be reduced by approximately 25 percent.

The year 2030 average day effectiveness of this measure is 3.370 mgd and the net economic effect is a benefit of $1,630,100 ($396,500 greater than Trial Proposal 4). The large increase in savings occurs because maximum day effectiveness is increased to a level allowing the delay of the initial Fargo water treatment plant expansion. None of the conservation measures implemented alone would reduce maximum day demand enough to delay this expansion.

Table 21 summarizes the trial proposals for the urban core. It shows that the sixth trial proposal provides the greatest benefit. Therefore, it is selected as the conservation proposal for the urban core communities to be integrated into the water supply plan.

C. PROPOSAL FOR RURAL COMMUNITIES

The list of measures eligible for inclusion in the water conservation proposal for the rural communities was shown earlier in Table 20. These measures are now combined one at a time to form trial proposals. The results of the evaluation of the trial proposals are summarized in Table 22 following the discussion of the trial proposals for the rural communities.

1. First Trial

The first trial proposal for the rural communities consists of the retrofit distribution and installation measure. The effects shown in Table 22 are essentially the same as those previously described for this measure in Chapters VI-IX. This trial proposal offers a year 2030 reduction in average day use of 0.061 mgd and has a beneficial net NED effect of $23,200 per year when combined with the Phase 2 water supply plan.

2. Second Trial

The second trial consists of retrofit distribution and installation and a peak demand pricing measure. No interactions between these two measures that would decrease the effectiveness of this additional measure are anticipated. The

TABLE 21

SUMMARY EVALUATION OF WATER CONSERVATION PROPOSALS - URBAN CORE COMMUNITIES

NED Effect	Trial Proposal No. 1	Trial Proposal No. 2	Trial Proposal No. 3	Trial Proposal No. 4	Trial Proposal No. 5	Trial Proposal No. 6
Year 2030 Annual Average Day Reduction (mgd)	1.702	2.365	2.365	2.692	2.753	3.370
Economic Disadvantages (Costs)						
Implementation Costs	142,200	152,500	152,500	167,700	191,200	170,200
Total NED Disadvantages	142,200	152,500	152,500	167,700	191,200	170,200
Economic Advantages (Benefits)						
Energy Savings	640,800	851,600	851,600	924,600	932,500	924,600
Additional Economic Effects	--	--	--	--	--	--
Foregone Supply Costs	331,600	445,600	445,600	476,700	487,500	875,700
Total NED Advantages	972,400	1,297,200	1,297,200	1,401,300	1,420,000	1,800,300
Net Economic Effect	830,200	1,144,700	1,144,700	1,233,600	1,228,800	1,630,100

NOTE: All economic impacts shown are annualized values in 1984 dollars.

combined effectiveness is a 0.085 mgd reduction in year 2030 average day use and the beneficial net NED effects are $30,100 per year, $7,100 more than Trial Proposal 1.

3. Third Trial

The third trial consists of the retrofit distribution and installation and a peak demand pricing structure plus the retrofit distribution measure. No additional reductions are gained by the inclusion of the latter measure, since the retrofit distribution and installation measure already included utilizes the same means of conservation more effectively for greater reductions. Therefore, the reductions for this trial proposal shown in Table 22 are the same as for the first trial.

No additional effectiveness or cost would be realized by including retrofit distribution in the final proposal. Therefore, to include retrofit distribution would be redundant and this measure is not included in subsequent proposals.

4. Fourth Trial

The fourth trial consists of the measures in the second trial proposal plus the water-saving fixtures measure. The interaction between the retrofit distribution and installation measure and the water-saving fixtures measure is assumed to cancel 90 percent of the latter measure's effectiveness, as previously described in trial proposals for urban core communities.

The additional reduction over the second trial proposal amounts to only 0.003 mgd and, because of the added costs, there is an annual negative net NED effect relative to Trial Proposal 2 of $400 per year. For this reason, the water-saving fixtures, measure is not considered in subsequent trial proposals.

5. Fifth Trial

The fifth trial proposal for the rural communities is composed of the measures of Trial Proposal 2 plus the education measure. The effectiveness of the education measure is reduced by interactions with the retrofit distribution and installation measure, as previously described in proposals for the urban core communities.

This interaction limits the combined effectiveness to a 0.099 mgd reduction in year 2030 average day use. The total beneficial net NED effect for this proposal is $29,600 per year. The added cost associated with education causes a negative net NED effect relative to Trial Proposal 2 of $500 per year. For this reason, Trial Proposal Five is dropped from further consideration.

Table 22 summarizes the effects of the different trial proposals for the rural communities. It indicates that the second trial proposal offers the greatest beneficial net NED effect. It is composed of the retrofit distribution and installation and pricing measures. This trial proposal is selected as the proposal for the rural communities for integration into the Phase 2 water supply plan.

TABLE 22

SUMMARY EVALUATION OF WATER CONSERVATION PROPOSALS - RURAL COMMUNITIES

NED Effect	Trial Proposal No. 1	Trial Proposal No. 2	Trial Proposal No. 3	Trial Proposal No. 4	Trial Proposal No. 5
Year 2030 Annual Average Day Reduction (mgd)	0.061	0.085	0.085	0.088	0.099
Economic Disadvantages (Costs)					
Implementation Costs	6,000	10,000	10,000	10,800	13,800
Total NED Advantages	6,000	10,000	10,000	10,800	13,800
Economic Advantages (Benefits)					
Energy Savings	25,400	35,300	35,300	35,600	38,200
Foregone Supply Costs	3,800	4,800	4,800	4,900	5,200
Total NED Advantages	29,200	40,100	40,100	40,500	43,400
Net NED Effect	23,200	30,100	30,100	29,700	29,600

NOTE: All economic impacts shown are annualized values in 1984 dollars.

XI. INTEGRATED WATER SUPPLY/CONSERVATION PLAN

This chapter presents the integrated water supply/conservation plan for the study area. Following the presentation of the plan, its effectiveness is discussed for each water use dimension and the economic advantages and disadvantages are described in detail. These effects are presented separately for the two groups of study area communities, urban core and rural.

A. GENERAL

The integrated water supply/conservation plan is framed on a water supply plan selected from Phase 2 [Alternative VI (SRR)]. Both plans use a subregional supply facility to serve the urban core communities and local expansions to serve rural communities. However, the integrated plan utilizes conservation proposals that change the scale and timing of water facility construction, and in some cases, eliminates facilities required in the Phase 2 plan. The integrated plan assumes that all reductions resulting from conservation are first used to reduce the development of the most costly sources. The enlarged dam is the first development curtailed, followed by Buffalo Aquifer groundwater development. Alternative schemes for crediting these reductions do not offer as great a NED benefit. One example would be to scale down surface water withdrawals, thereby maintaining slightly higher streamflows.

In both the integrated plan and the Phase 2 plan, the four urban core communities are coordinated into a subregional system whereby they share all new water supplies. These communities continue to use their existing facilities and sources of supply, but new water sources and facilities are developed in a more cost-effective manner. The subregional organization avoids redundant systems and generates other efficiencies. Under these plans, Fargo would expand its treatment plant primarily to accommodate the new surface water needs of the urban core communities, and Moorhead would expand its facilities primarily to

treat the additional ground-water needs during drought. Thus, West Fargo and Dilworth would not have to build their own treatment plants and the most economical mix of surface and ground water could be used at all times.

The integrated plan and the Phase 2 plan are outlined in Table 23. Sources of water for the integrated plan include the existing sources and new ground-water development. Assuming the existing reservoir behind the low-head dam on the Red River is capable of providing 450 acre-feet of usable storage, the reservoir would not have to be enlarged. A future study should be conducted to determine usable storage and characteristics of sedimentation.

New ground water for the integrated plan is supplied by further developing the Kragnes, Moorhead, and Buffalo Aquifers. The Kragnes and Moorhead Aquifers will be developed with facilities capable of producing the full safe yield of these resources (0.09 billion gallons per year (bgy) and 0.44 bgy respectively). Buffalo Aquifer development would have to be expanded to produce 0.61 bgy and the West Fargo Aquifer would be curtailed to its safe yield of 0.44 bgy for a total annual yield of 1.58 bgy from the area's aquifers.

Surface water sources for the integrated plan include the Red and Sheyenne Rivers. The existing surface water intakes for Fargo and Moorhead on the Red River would be retained and expanded. Moorhead's expansion may be designed to optimize the mix of the city's surface and ground-water sources under peak demand conditions. Fargo would treat both Red and Sheyenne River water. The Sheyenne supplies are transmitted to Fargo via the existing Sheyenne pipeline.

The integrated plan uses the SRR operating plan based on low-flow criteria set by the Souris-Red-Rainy River Basins Comprehensive Study.

TABLE 23

OUTLINE OF INTEGRATED WATER SUPPLY/CONSERVATION PLAN

	Existing Water Supply	Phase 2 Water Supply Plan	Integrated Water/Supply Conservation Plan
West Fargo Aquifer	1.50 mgd	1.20 mgd	1.20 mgd
Moorhead Aquifer	0.33 mgd	1.20 mgd	1.20 mgd
Kragnes Aquifer	0.22 mgd	0.25 mgd	0.25 mgd
Buffalo Aquifer*	1.06 mgd	3.80 mgd	1.68 mgd
Red River Reservoir	450 ac-ft	1,200 ac-ft	450 ac-ft
Treatment Capacity	34 mgd	57 mgd	43 mgd

*Does not include 0.20 mgd used by smaller communities and rural users.

Under normal operations, the rivers and ground-water sources would be used to meet demands until either streamflows below the municipal intakes decline to 30 percent of mean annual flow or ground-water withdrawals reach 95 percent of the safe yield rate. Once either threshold is reached, additional demand will be satisfied by drawing on the other source until its threshold is also reached. This operating plan would help maintain aquatic resources because it uses ground water sources prior to withdrawing surface water below 30 percent of the mean annual flow and minimizes the time that flows are below this condition.

When streamflows below the municipal intakes fall to 30 percent of mean annual flow and ground-water withdrawals reach 95 percent of the safe yield rate, additional demands would be satisfied by drawing on river flows. These additional demands would be divided equitably among the two rivers so that each would be reduced to the same percent of mean annual flow. In no case, however, would flows be drawn upon below the low-flow criteria of 7 cfs in the Red River and 3 cfs in the Sheyenne. When these minimum in-stream flows are reached, withdrawals from the reservoir would begin to augment supplies during daily peak periods. The bulk of the daily needs could be satisfied by pumping aquifers at up to double their safe yield rates for short periods of time. This procedure would not cause any long-term depletion of the supply, because after each critical period, pumping rates would return to no more than 95 percent of the safe yield rate.

B. EFFECTIVENESS

The effectiveness of the integrated plan is shown in Table 24. These reductions in water use were used to estimate the energy savings and foregone supply costs presented in later portions of this discussion.

TABLE 24

EFFECTIVENESS OF SELECTED WATER CONSERVATION PROPOSALS
- flow in mgd -

Conservation Measure	Year 2000 Seasonal Use	Year 2000 Average Day Use	Year 2000 Maximum Day Use	Year 2000 Consumptive Use	Year 2000 Average Day Sewer Contribution	Year 2030 Seasonal Use	Year 2030 Average Day Use	Year 2030 Maximum Day Use	Year 2030 Consumptive Use	Year 2030 Average Day Sewer Contribution
Urban Core Communities										
Use without Conservation	2.515	20.904	44.628	6.900	16.269	3.056	26.329	56.428	8.641	19.988
Effectiveness	(0.928)	(2.692)	(11.804)	(0.928)	(1.764)	(1.077)	(3.370)	(13.617)	(1.077)	(2.293)
Resultant Use	1.587	18.212	32.824	5.972	14.505	1.979	22.959	42.811	7.564	17.695
Rural Communities										
Use without Conservation	0.072	0.432	0.864	0.109	0.300	0.092	0.590	1.180	0.142	0.393
Effectiveness	(0.005)	(0.066)	(0.119)	(0.005)	(0.051)	(0.006)	(0.085)	(0.156)	(0.006)	(0.065)
Resultant Use	0.067	0.366	0.745	0.104	0.249	0.086	0.505	1.024	0.136	0.328

NOTE: Effectiveness values in parentheses represent reductions in water use.

The general effect of conservation can be visualized by considering the reductions in average day use. Long-term water conservation measures in the proposals reduce average day use by approximately 13 percent in the urban core and 14 percent in the rural communities.

C. ECONOMIC ADVANTAGES AND DISADVANTAGES

Economic advantages include energy savings and foregone supply costs. Energy savings are measure-specific effects that do not involve knowledge of the water supply plan; however, foregone supply costs are determined based on the water supply plan.

The process of determining the foregone supply costs for wastewater facilities is exactly as previously described for individual measures in Chapter VIII. Foregone supply costs for water supply facilities is the difference in annual costs between the Phase 2 water supply plan and the integrated water supply/ conservation plan. Table 25 presents detailed costs for the integrated water supply/conservation plan and identifies the estimated cost savings. A graphical picture of the timing of these costs is presented in Figure 6. The different components of the foregone costs are highlighted in this discussion.

The short-run incremental costs include power and/or chemical costs that will be saved by handling/treating smaller amounts of water. Long-run cost savings include delayed or eliminated capital costs associated with construction of water facilities. The savings in water treatment plant expansion costs for the urban core communities are primarily attributable to delayed construction of clarifiers, pumping equipment, and other facilities. Conservation allows the urban core to save by reducing the size of the required aquifer expansions. Some wells, feeder pipelines, and pumps may be eliminated and certain phases of remaining construction delayed. The expansion of the low-head dam on the Red

TABLE 25

INTEGRATED WATER SUPPLY/CONSERVATION PLAN
DETAILED COST ESTIMATES

Approximate Timing	Facilities	Construction* Cost	O, M and R Costs
1985	Fargo-West Fargo Connection	$ 378,000	$ 6,100
	Moorhead-Dilworth Connection	$ 31,000	$ 500
1990	Fargo-Moorhead Connection	$ 468,000	$ 4,800
	Dilworth Elevated Storage (0.4 mg)	$ 450,000	$ 2,300
	Sabin Well, Ground Storage and Booster Pump	$ 235,000	$ 6,600
	Glyndon Ground Storage and Booster Pump	$ 188,000	$ 2,700
	Riverside Well, Ground Storage and Booster Pump	$ 140,000	$ 6,000
	Horace, Ground Storage and Booster Pump	$ 116,000	$ 1,600
2004	Fargo Water Treatment Plant Expansion (5 mgd)	$ 3,180,000	$ 175,200
	Fargo Raw Water Piping Expansion	$ 71,000	$ 700
2010	Horace Well	$ 47,000	$ 3,100
	Sabin Pump Replacement	$ 46,000	$ --
	Glyndon Pump Replacement	$ 49,000	$ --
	Riverside Pump Replacement	$ 25,000	$ --
2018	Moorhead Well Field Expansion (0.9 mgd)	$ 230,000	$ 14,000
	Moorhead Water Tratment Plant Expansion (4 mgd)	$ 2,030,000	$ 155,000

TABLE 25 (continued)

INTEGRATED WATER SUPPLY/CONSERVATION PLAN

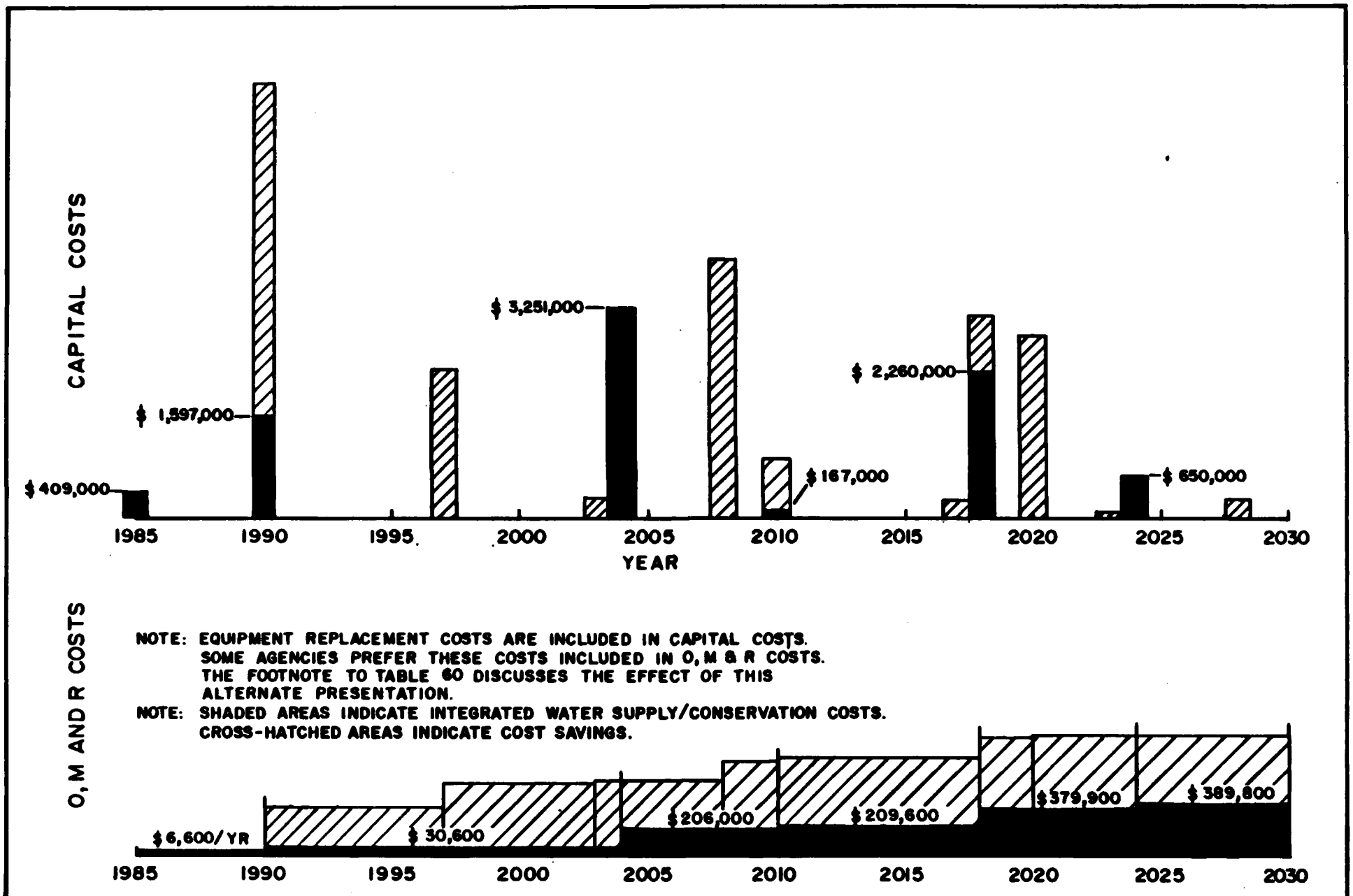
DETAILED COST ESTIMATES

Approximate Timing	Facilities	Construction* Cost	O, M, and R Costs
2024	Buffalo Well Field Expansion (0.6 mgd)	$ 184,000	$ 9,800
	Fargo WTP Equipment Replacement	$ 466,000	--
	TOTAL	$ 8,334,000	$ 389,800
	Present Value Equivalent	$ 1,995,000	$ 555,000
	Uniform Annual Equivalent	$ 189,700	$ 52,800

FOREGONE SUPPLY COSTS

	Phase 2 Water Supply Plan	Integrated Water Supply/ Conservation Plan	Foregone Water Supply Costs
Present Value	$9,045,000	$2,550,000	$6,495,000
Annual Equivalent	$ 860,000	$ 242,500	$ 617,500

*Equipment replacement costs are included in construction costs. Some agencies prefer these costs included with O, M, & R costs. Including these costs with O, M, & R would increase the O, M, & R present value equivalent by $25,000 and the uniform annual equivalent by $2,400. It would decrease the construction costs by the same amount, leaving the total present value and uniform annual equivalents unchanged. The capital costs shown in Figure 6 would be decreased, but corresponding capital outlays to the O, M, & R costs would be added.



FARGO-MOORHEAD URBAN WATER SUPPLY/CONSERVATION INVESTIGATIONS

INTEGRATED WATER SUPPLY/CONSERVATION PLAN
CAPITAL OUTLAYS

E.A. HICKOK & ASSOCIATES
HYDROLOGISTS-ENGINEERS
MINNEAPOLIS-MINNESOTA

fig. 6

River may also be completely eliminated (assuming that 450 acre-feet of storage could be maintained behind the existing structure). Finally, wastewater treatment plant expansions can be delayed to provide additional savings. Urban core communities could delay construction of digestor tanks, pumps, settling basins, and other facilities. Rural communities could delay expansion of stabilization ponds.

Total economic benefits are determined by adding energy savings to the foregone supply costs and subtracting the implementation costs. Table 26 provides a summary of total cost savings associated with the integrated water supply/conservation plan.

The implementation costs of the water conservation proposal for the urban core are approximately $10,000 per year less than the sum of the costs of the individual measures. This is primarily because educational efforts required for each measure are consolidated.

D. IMPACT ASSESSMENT

Potential environmental and social impacts of the selected water conservation proposals include increased water rates and reduced wastewater return flow volumes. The size of the potential increase in water rates is site-specific and would be determined individually for each municipality by a separate rate study. Therefore, this effect is not quantifiable. The effect of reduced wastewater return flows can be more directly addressed.

When the conservation proposal is integrated into the Phase 2 supply plan (plan without conservation), the demands on the water source are reduced as well as the return flow from the treatment plant. Return flows from the urban core communities would be reduced by the amount of reduction in average day sewer contributions, 2.293 mgd, or 3.55 cfs, in year 2030 (see Table 24). This reduction is equivalent to approximately 70 percent of the total anticipated

TABLE 26

INTEGRATED WATER SUPPLY/CONSERVATION COST SAVINGS

- annualized savings in 1984 dollars -

Cost Component	Urban Core	Rural	Total
Short-Run Incremental Costs:			
Water Treatment Plant, Supply and Distribution	$247,100	$ 400(1)	$247,500
Wastewater Treatment Plant	30,000		30,000
Long-Run Incremental Costs:			
Water Treatment Plant Expansion	326,300		326,300
Aquifer Expansion	33,400		33,400
Low-Head Dam Expansion	10,700		10,700
Wastewater Treatment Plant Expansions	228,200(2)	4,400	232,600
Total Foregone Supply Costs	$875,700	$ 4,800	$880,500
Energy Cost Savings	$924,600	$35,300	$959,900
Implementation Costs	-170,200	-10,000	-180,200
Total Savings	$1,630,100	$30,100	$1,660,200

(1)Includes only power for water supply.

(2)Fargo and West Fargo only.

reduction in average day use. Thus, downstream of the wastewater treatment plant outfalls, the average return flow would be reduced by less than 12 percent.

An example of the the effect of this reduction on Red River flows is shown in Table 27. This table displays flows between intakes and outfalls and below outfalls for the plan without conservation (the preferred Phase 2 plan) and two combinations of water supply facilities that consider conservation. The analysis uses the SRR operating plan previously described.

When the 5 cfs reduction in water use generated by conservation is used to curtail ground-water development and associated facilities, the greatest NED benefit occurs. However, if this same 5 cfs is used to curtail surface-water development, Red River flows would be 5 cfs greater under normal conditions. This would allow slightly higher in-stream flows reducing the duration of sub-standard flows, in turn, benefiting aquatic resources. With 50-year, 7-day low flows, the Red River discharge is less than 1 cfs. The Phase 2 Water Supply Plan ensures a flow of at least 7 cfs in this case. Without conservation return flows of the urban core communities discharging into the Red River are near 28 cfs. Conservation reduces streamflows below the outfalls by approximately 10 percent. These flows are approximately 31.5 cfs whether ground-water or surface-water development is curtailed.

TABLE 27

EFFECT OF CONSERVATION ON RED RIVER FLOWS*

Flow Condition	Flow Condition Above Raw Water Intakes (cfs)	Flow Conditions Below Intakes and Above Outfalls (cfs)			Flow Conditions Below Treated Wastewater Outfalls (cfs)		
		Plan Without Conservation	Curtailed Ground Water Development	Curtailed Surface Water Development	Plan Without Conservation	Curtailed Ground Water Development	Curtailed Surface Water Development
Normal Conditions (Lowest average monthly flow-January)	180	149	149	154	177	173	178
Drought Conditions (Lowest 50-year drought flow)	<1	7	7	7	35	31	31

*This analysis is based on the Phase 2 water supply plan with the SRR operating plan (plan without conservation). (See the Phase 2 report, "Alternate Sources and Treatment/Distribution Systems," particularly Tables 57 and 58 for further details.)

NOTE: Curtailed ground-water and surface-water development refers to utilizing the reductions attributable to conservation to reduce ground or surface water demands and facilities associated with the plan without conservation.

XII. DROUGHT EMERGENCY PLANS

A. GENERAL

Drought emergency plans for the urban core and rural communities were previously developed in Phase 2. These plans are presented and thoroughly discussed in the Phase 2 report. The emergency plans are framed on a selected Phase 2 water supply plan, Alternative VI (SRR). This plan utilizes a subregional water supply system for the urban core and an operating plan associated with the Souris-Red-Rainy River Basins Comprehensive Study. It is described in detail in the Phase 2 report. The integrated water supply/conservation plan presented in the previous chapter is capable of meeting the 50-year drought. Thus, the purpose of the drought emergency plans is to complement the Phase 2 water supply plan so that water supply capabilities could be extended to meet more severe droughts through conservation.

In the previous chapter, a long-term water conservation proposal was selected and integrated into the Phase 2 water supply plan. The water supply facilities were scaled down by an amount equivalent to the reductions in water use caused by conservation. Therefore, the integrated plan still retains the capability to meet the water demands of the projected 50-year drought. However, since long-term conservation measures are now integrated into the water supply plan, the drought emergency plans previously proposed in Phase 2 must be re-evaluated. The purpose of this re-evaluation is to ensure that the conservation measures in the drought emergency plan are effective and capable of extending the water supply capabilities to more severe events, particularly the 100-year drought.

This issue is really one of reliability. The Phase 2 water supply plan without conservation has all of the potential conservation measures available for inclusion in its drought emergency plan. The drought emergency plan associated with the integrated water supply/conservation plan developed in Phase 3 can only

include measures compatible with those already integrated into the water supply plan. There is no loss in reliability if both drought emergency plans are capable of extending water supply capabilities beyond the 100-year drought. Based on results of the earlier phases of this study, an additional reduction equivalent to 10 percent of the year 2030 average use should achieve this goal.

Measures appropriate for inclusion in the drought emergency plan are termed contingent measures. These measures must be effective, capable of rapid implementation, and socially acceptable (perceived by the public as warranted and equitable considering the severity of the water shortage).

Contingent measures are implemented only under pre-specified conditions, and then only for a limited time span. They are basically crisis-oriented, so they must be capable of rapid implementation. Contingent measures are typically more severe than long-term measures; however, any duress that they may impose should be balanced by the potentially harmful impacts of the water shortage that these measures help avert.

B. EVALUATION OF CONTINGENT WATER CONSERVATION MEASURES

Possible contingent measures for the urban core and rural communities are listed in Table 28 and are discussed in detail in Chapter V. The list includes measures that are not socially acceptable on a long-term basis, but are "potentially" acceptable when applied for a short time under severe drought conditions. Also listed are potential long-term measures that are not ultimately included in the water supply/conservation plan.

Measures underlined are considered potential contingent measures based on the criteria of capability of rapid implementation and effectiveness. A third criterion, social acceptability, is considered for measures meeting the first two criteria.

TABLE 28

POTENTIAL CONTINGENT MEASURES

	Capable of Rapid Implementation	Effective
Metering*	No	--
Meter Maintenance	Potentially	Potentially
Leak Detection and System Maintenance	Potentially	Potentially
Economic Incentives	Yes	NA
Water-Saving Fixtures	No	--
Pricing		
- Penalty Charges	Yes	NA
Sprinkling Ordinances*	Yes	Yes
Restrictions Rationing Use	Yes	Yes
Restrictions Determining Priority Use	Yes	Yes
Educational Measures*	Yes	NA

*Complete conservation programs associated with this measure are applicable only to rural communities.

NOTE: The criterion of effectiveness is not applicable (NA) to economic incentives, penalty charges, and educational measures because they are considered only as vehicles to implement other contingent measures.

Meter maintenance and leak detection are shown as potentially capable of rapid implementation. This is because the utility can act independently and initiate the implementation of these measures on short notice. The potential effectiveness depends on how quickly these measures can be fully implemented.

Metering and, particularly, the water-saving fixtures measures require lengthy periods of phased implementation. It might be possible for Glyndon or Sabin (the two rural communities considered for the metering measure) to meter only their larger customers on short notice. However, 90 percent of their demand is residential use and it would surely be socially unacceptable to meter only a portion of the residential community. Therefore, these two measures are not considered further.

Meter maintenance and leak detection and system maintenance are both shown as being potentially capable of rapid implementation. This means that on short notice, these actions can be initiated, although they may not become fully implemented. They may be quickly initiated because efforts quite similar to these measures are currently in use by most study area communities and these efforts are under direct control of the utility. Thus, an increase in replacement of mis-registering meters and location and repair of leaks in the distribution system can be accomplished relatively quickly. However, their effectiveness depends on how quickly they can be fully implemented. These measures are not characteristically fully implemented in a short period of time. For these reasons, they are shown in Table 28 as potentially effective. These measures are important to the success of the emergency plans because of the public awareness associated with them. Meter maintenance and leak detection are both very socially acceptable, and they demonstrate a vital resolve on the part of the utility; it shows the public that the utility is also making its conservation contribution. This helps to clearly convey the serious nature of the shortage to the community.

Economic incentives and penalty charges were previously considered as vehicles for implementing other water conservation measures. They are not considered as measures in themselves.

The penalty charges are an implicit part of the enforcement policy for contingent ordinances or regulations which may be adopted. Economic incentives, though not part of a specific measure, act to encourage conservation through any measure reducing a consumer's bill. Education must accompany any measure requiring public support, particularly in contingent situations where a rapid response is required.

Of the remaining measures, restrictions determining priority use and restrictions rationing use are applicable only to the urban core communities. These measures are seen as mutually exclusive.

Restrictions determining priority use ban certain uses. The common application is to ban all non-essential uses, primarily outdoor uses such as lawn watering and car washing. Thus, bans mainly affect the residential sector; commercial and public users are less affected.

Bans are not very flexible; they prohibit certain uses, and one cannot partially ban a use. The social acceptability of bans is reported to be satisfactory if the public is convinced of the need for this restriction. Special concerns in the study area may make it difficult to establish public understanding about this type of measure. As previously described in Chapter IV, there is a strong agricultural influence in the area, and lawns and gardens are a source of community pride. If people were given a choice, they might choose to reduce or eliminate other uses by an equivalent amount. In addition, bans on outdoor use are not capable of reducing average daily use more than 8 percent. Considering the potential additional reductions from increased meter maintenance and leak detection, this measure would still not meet the 10-percent goal.

Restrictions rationing use are capable of producing reductions in excess of 10 percent. Water rationing can be implemented very rapidly with some advance planning. This work would include the choosing of a specific method of rationing, partitioning the reductions among the consuming sectors, and conducting a good public education campaign. One successfully established rationing program set a base allocation for residences and added a certain amount for each occupant. Fixed percentage reductions were used for commercial and industrial users (AWWA, 1980).

Rationing is generally more popular with the public than restrictions prohibiting specific consumer actions (such as a total ban on lawn watering) (AWWA, 1981). This is because a rationing plan allows consumers to choose priorities of water use. Thus, with rationing, some water could still be used for irrigation, and the strong social concerns for lawns and gardens would not be so adversely affected. Rationing is also flexible. It could be phased in as a voluntary measure and intensified or lifted according to the changing drought conditions. This phased treatment could avert the need for enforcement during the voluntary phase. Possibly the flexibility of the program would provide enough latitude for consumers that no enforcement would be necessary during either phase. Reports from many California communities indicate that public support during severe water shortages is so strong that the rationing goal is often exceeded (Richards, 1984).

Based on this evaluation, adapted forms of the meter maintenance and leak detection measures, along with restrictions rationing use, have been retained as contingent measures for integration into the drought emergency plan for the urban core communities. Penalty charges, economic incentives, and certain aspects of educational measures are implicitly included as previously discussed in this subsection.

Contingent measures for the rural communities can be selected by applying the same rationale as previously used for the urban core communities. Accordingly, adapted forms of the meter maintenance and leak detection measures would be retained along with either restrictions rationing use or water use bans. In rural communities, two additional measures -- sprinkling bans and education -- are also available to mitigate any adverse social impacts of rationing of water use bans.

Water use bans are probably the best choice for the drought emergency plans for the rural communities. Seasonal water use, composed primarily of residential irrigation, makes up approximately 12 percent of the total average use after accounting for interactions with the long-term conservation proposal. Therefore, bans on non-essential use could be sufficiently effective. The design and enforcement of a rationing system may be a drain on a small community's resources, while a ban may be a more straightforward program and sufficiently effective.

A rural community could apply sprinkling ordinances when water shortages begin and, if the severity increases, invoke a ban on non-essential water use. This scheme may be favored by the smaller communities because it is less complex. The sense of civic responsibility runs strong in small communities and peer pressure may preclude the need for the expensive enforcement often associated with a ban.

Education can also mitigate the impacts of a ban. In small communities, it is possible to build support for contingent measures by explaining measures door-to-door or in public meetings.

Because of the great variation in characteristics of water supply among the rural communities, it is appropriate to offer a choice of emergency conservation programs: 1) a program built on a phased-in water rationing plan exactly like

the urban core plan, and 2) a less complex program with a sprinkling ordinance to phase in a water use ban.

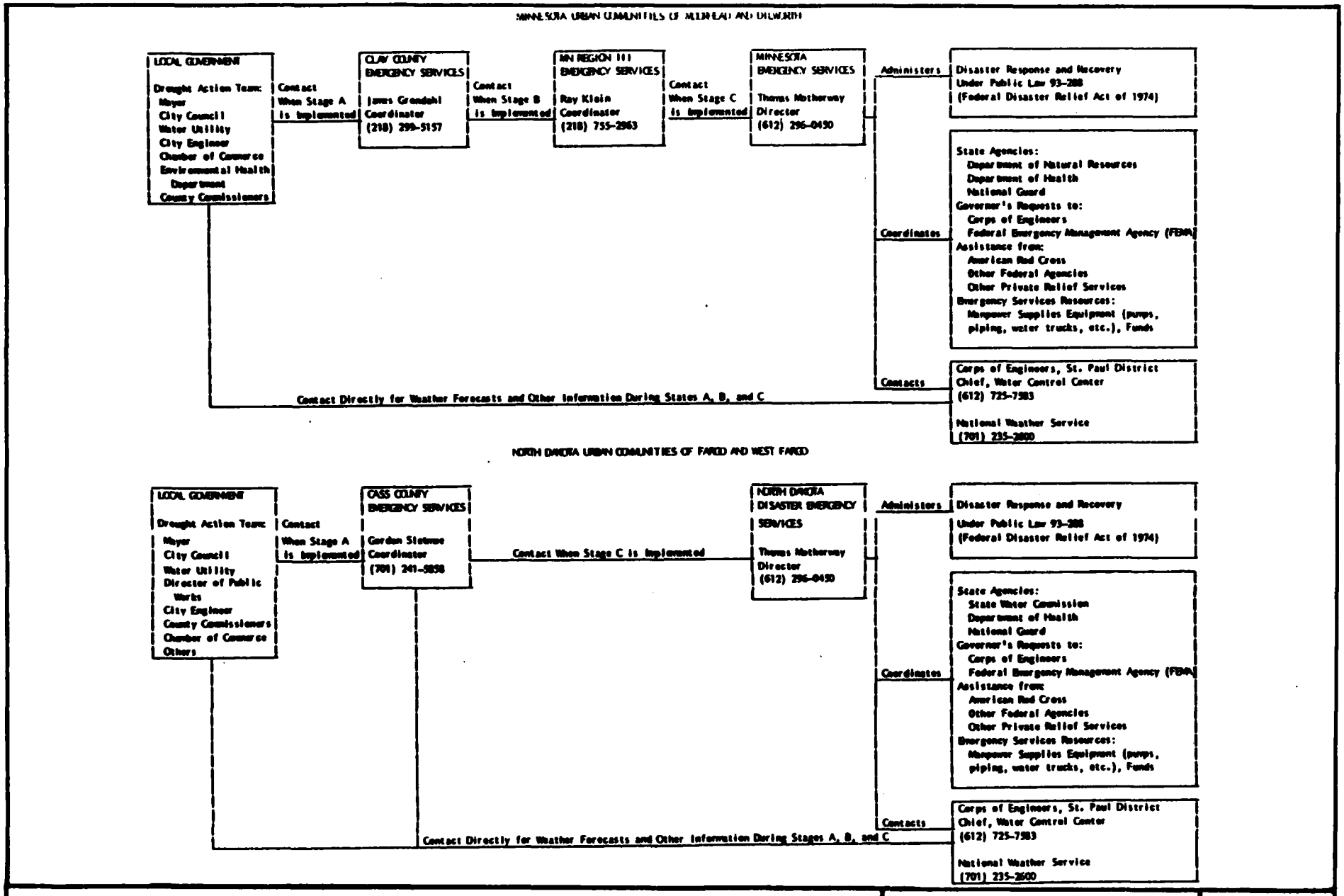
C. DROUGHT EMERGENCY PLANS

1. Drought Emergency Plans for the Urban Core Communities

The drought emergency plans for urban core communities are intended to address conditions encountered during a 50-year drought. Effective public sector actions are vital to the success of drought emergency plans. The current supply conditions must be analyzed and the public must be well informed about the drought and what actions are to be taken.

All stages in the drought emergency plan utilize a network of contacts necessary to disseminate and obtain information pertinent to local drought actions. This network is described in detail in the Phase 2 report. Figure 7 displays the networks for Minnesota and North Dakota urban core communities. The three important stages in this Drought Emergency Plan are outlined in Table 29 and described in detail in the following discussion.

Stage A is implemented when the sum of the available ground-water and streamflow supplies just equals the demands of the urban core communities. Available ground water consists of withdrawals at 95 percent of the safe yield rates from the Buffalo, West Fargo, Moorhead, and Kragnes Aquifers less other major uses. Available streamflow includes the combined Red and Sheyenne River flows less the 7- and 3-cfs minimum in-stream flows designated by the Souris-Red-Rainy River Basins Comprehensive Study. Additional deficits caused by the continuing drought conditions must be met from storage. This storage includes the in-stream storage behind the low-head dam on the Red River and the volume of water reserved in the developed aquifers by limiting average annual withdrawals to 95 percent of safe yield.



FARGO-MOORHEAD URBAN WATER SUPPLY/CONSERVATION INVESTIGATION

DROUGHT ACTION ORGANIZATION CHART

E.A. HICKOK & ASSOCIATES
HYDROLOGISTS-ENGINEERS
MINNEAPOLIS-MINNESOTA

fig. 7

TABLE 29

DROUGHT EMERGENCY PLAN - URBAN CORE COMMUNITIES

CURRENT CONDITIONS	PUBLIC SECTOR ACTIONS
STAGE A	
Combined supplies from all sources utilized under standard operating conditions approach 100 percent of the demand of the urban core communities: The following aquifers are being pumped at rates of 95 percent of safe yield: Buffalo Aquifer West Fargo Aquifer Moorhead Aquifer Kragnes Aquifer Remaining urban core demands are able to be made up by supplies from municipal treated water storage and flows in the Sheyenne and Red Rivers (less minimum in-stream flows of 7 and 3 cfs, respectively).	Information/Education 1. Drought Action Team activates the chain of contacts outlined in Drought Action Organization Chart (Figure 6) informing them of changing supply conditions. Streamflow forecast information is then compiled from data furnished by contacts in the Army Corps of Engineers. 2. Cities and utilities publicize current status which could limit system capabilities, as well as costs of supply augmentation for the utility and consumers. Implement Conservation Programs 1. Cities have already implemented their long-term water conservation measures integrated into the Phase 2 water supply plan. 2. Utilities increase monitoring and maintenance of water meters. 3. Utilities step up leak detection and repair programs.

TABLE 29 (continued)

DROUGHT EMERGENCY PLAN - URBAN CORE COMMUNITIES

CURRENT CONDITIONS	PUBLIC SECTOR ACTIONS
STAGE B	
Streamflows in the Red and Sheyenne Rivers approach minimum in-stream flows of 7 and 3 cfs after withdrawals for municipal use. The combined supply from sources outlined in Stage A is less than the demands of the urban core communities. The storage behind the existing low-head dam in the Red River must now be utilized to cover daily peak deficits and the aquifer storage reserved for drought contingencies must be utilized to cover supply deficits.	Continue education and programs implemented in Stage A with the following additions: Information/Education 1. Mayors declare drought emergency. 2. Drought Action Team notifies contacts as shown in the Drought Organization Chart about use of additional supply sources. 3. Drought Action Team and utilities intensify public education explaining new supply augmentation methods using established channels of communication (billing inserts, etc.). Costs associated with potential actions in succeeding stages of drought are expressed. 4. Utilities and cities distribute conservation booklets explaining less wasteful practices of water use and describing potential public actions in following stages. 5. Public education is expanded to include the explanation of general conservation techniques and enforcement policies for restrictions. Implement Conservation Programs 1. Cities advocate voluntary rationing to produce reductions of up to 10 percent. 2. Drought Action Team requests ground-water permitting authorities (Minnesota Department of Natural Resources and North Dakota State Water Commission) to survey current users and frequently monitor all major users.

TABLE 29 (continued)

DROUGHT EMERGENCY PLAN - URBAN CORE COMMUNITIES

CURRENT CONDITIONS	PUBLIC SECTOR ACTIONS
STAGE B (continued)	3. Cities advocate voluntary retrofit as part of the retrofit distribution and installation measure. Free water-saving devices in retrofit kits, including toilet dams, low-flow buttons, and faucet aerator inserts are made available at distribution depots. 4. Cities discontinue use of fire hydrants other than for extinguishing fires. 5. Cities survey large commercial and industrial users and request reduction in non-essential water uses.

TABLE 29 (continued)

DROUGHT EMERGENCY PLAN - URBAN CORE COMMUNITIES

CURRENT CONDITIONS	PUBLIC SECTOR ACTIONS
STAGE C	
Low-head storage is completely depleted. Aquifer storage supplies developed in prior stages are reduced to 70 percent of original capacity.	Continue education and programs implemented in previous stages with the following additions. Information/Education 1. Drought Action Team notifies established contacts on the status of remaining supplies. 2. Cities and utilities establish "high profile" education campaign including contests, billboards, speakers, and school programs. 3. Cities post water conserving signs in public places. Implement Conservation Programs 1. Drought Action Team requests frequent reports on withdrawals by all ground-water users and carefully monitors the depletion of remaining supplies via ground-water permitting authorities. 2. Cities invoke mandatory rationing to produce reductions of 10 percent of average annual use.

The public sector has already utilized the long-term measures implemented into the Phase 2 water supply plan. New public sector actions include information/education campaigns and the utilities' supply management water conservation programs. In Stage A, the Drought Action Teams meet in the Minnesota and North Dakota portions of the urban area. The teams contact the County Emergency Services Offices and assist the cities in publicizing the current status of water supply facilities. In Stage A, their primary purpose is to alert the public of potential water shortages. The utilities increase their maintenance and repair programs to reduce losses and demonstrate a commitment to mitigate any potential shortages.

Stage B is implemented when the combined supply from the sources outlined in Stage A is less than the demands of the urban core communities. The low-head storage behind the existing Red River low-head dam must now be utilized to cover daily peak deficits and the aquifer storage reserved for drought contingencies must be utilized to cover the bulk of the supply deficits.

Public sector actions in Stage B include continuation of those activities begun in Stage A. Urban core mayors declare a drought emergency. New education and conservation programs focus on informing the public about the status of water facilities and request voluntary conservation. Data required to monitor ground-water withdrawals are requested from State agencies. Utility billing inserts and conservation booklets are now used to explain conservation techniques, drought-related costs, and potential actions in succeeding stages. A voluntary water rationing program advocating a reduction equivalent to 10 percent of the total municipal average day use is called for. Rationing

programs may be based on average annual or winter water use, a per capita use value, or a fixed or variable percentage reduction across all user sectors as discussed in Chapter V.

As part of the retrofit distribution and installation measure, a voluntary campaign to retrofit homes with water-saving devices is also begun. This is one of the periodic retrofit promotions used to refit homes that may have declined to be retrofit originally, or to replace devices that may have been inadvertantly removed. During water shortages, the willingness of people to take conservation actions is increased. Therefore, this is an opportune time to promote retrofit devices. These devices include toilet dams, low-flow aerators, and flow-reducing inserts and would be available free at a central depot. Reductions in other non-essential uses by residential, commercial, and industrial consumers are also requested. Accordingly, the city discontinues its non-essential uses such as fire hydrant flushing.

Stage C is the final stage in the Drought Emergency Plan. The low-head storage reservoir is completely depleted and 70 percent of the original aquifer storage remains. This value is based on safe yield data and reported pumping records.

A "high profile" public education program (including contests, billboards, speakers, and "water shortage -- please conserve" signs) is begun in addition to previous actions. Enforcement policies for mandatory conservation measures are also explained (Table 30). Frequent monitoring of ground-water pumping records and weather/streamflow forecasts is conducted to determine remaining aquifer storage and surface water supplies. Information may indicate a drought with a recurrence interval of 100 years or more is in progress. At this point, the

TABLE 30

DROUGHT/EMERGENCY CONSERVATION PLAN PENALTIES

Violation Occurrences	Prohibited Uses	Excess Uses
First	Written warning via regular mail.	Written warning via regular mail.
Second(1)	Written warning delivered by utility representative who will offer conservation tips and approved retrofit devices.	Surcharge. Written warning delivered by utility representative who will offer conservation tips and approved retrofit devices.
Third(1)	Flow restrictor (1 gpm) installed for 48 hours. Installation and removal charges assessed.	Surcharge. Flow restrictor (1 gpm) installed for 48 hours. Installation and removal charges assessed.
Additional (1)	Shutoff, plus reconnection charge of $25.	Surcharge. Shutoff, plus reconnection charge of $25.

(1)Within one year of first occurrence.

Drought Action Team and the utility must evaluate the available water supply and forecast data to determine the amount of any further reductions. These reductions may be achieved through an intensified rationing program.

Data developed for year 2030 indicate that a 10-percent reduction in annual average municipal use would make this Drought Emergency Plan capable of providing water supplies to the urban communities in events beyond a 100-year recurrence interval drought. Additional reductions may be necessary under certain site-specific conditions including contamination of a source of supply.

2. Emergency Water Supply Plan for Rural Communities

All rural communities obtain their water supplies from ground water. If they establish the facilities outlined in the Phase 2 report, they will be able to provide water to their residents through the year 2030. This assumes that there is no facility failure, aquifer contamination, or shortage related to heavy ground-water use by others. Water supply emergencies would involve reductions in water demand which can be achieved through public actions like those described in the drought emergency plans for the urban core communities and would provide a margin of safety in these emergencies. Other sources of emergency augmentation include trucked-in water and supplies available from the reactivation of older municipal or individual systems. The emergency plan presented here is a general plan for rural communities that can be adapted by local officials according to their special circumstances.

The Emergency Water Supply Plan for Rural Communities (Table 31) includes three stages. Each stage represents a means of compensating for the loss of a certain percentage of municipal water supply capability. Such losses may possibly occur through facility failure or damage to the resources, such as well field

TABLE 31

EMERGENCY WATER SUPPLY PLAN - RURAL COMMUNITIES

CURRENT CONDITIONS	PUBLIC SECTOR ACTIONS
STAGE A	
System facility/resource loss less than 10 percent of average annual demand.	Information/Education 1. Emergency Action Team reviews the situation and contacts the appropriate State Department of Health and County Emergency Services Office. 2. Emergency Action Team initiates public education, explaining current conditions and associated costs. The team distributes conservation booklets describing less wasteful practices of water use and use restrictions. Implement Conservation Programs 1. Community invokes ordinance restricting lawn sprinkling and all outdoor water uses to alternate days and off-peak hours. 2. Community promotes free retrofit kits of water-saving devices. 3. Community increases system management activities involving meter monitoring, leak detection, and repair.

TABLE 31 (continued)

EMERGENCY WATER SUPPLY PLAN - RURAL COMMUNITIES

CURRENT CONDITIONS	PUBLIC SECTOR ACTIONS
STAGE B	
System facility/resource loss is equivalent to 10 to 20 percent of average annual demand. Rural communities presently served by CRWUA reactivate older supply systems, if operational. Other communities encourage the use of existing individually-owned wells.	Implement Public Sector Actions of Stage A with the following additions: 1. Mayor declares emergency situation. 2. Emergency Action Team notifies contacts of current situation. 3. Community officials speak at public meetings to explain reduction actions, rationing program, and potential actions if situation should worsen. Implement Conservation Programs. 1. Community requests voluntary rationing to achieve additional reductions resulting in a savings of 10 percent of average annual use. or Community invokes ban on all non-essential water uses.

TABLE 31 (continued)

EMERGENCY WATER SUPPLY PLAN - RURAL COMMUNITIES

CURRENT CONDITIONS	PUBLIC SECTOR ACTIONS
STAGE C	
System facility/resource loss is more than 20 percent of average annual demand. Rural communities arrange for trucked-in water from other sources	Implement Public Sector Actions of Stages A and B with the following additions: Information/Education 1. Emergency Action Team notifies contacts of current situation. 2. Community officials go door-to-door to explain rationing guidelines and to point out appropriate reduction measures. Implement Conservation Programs 1. Community invokes mandatory rationing to achieve the additional reductions.

contamination. In actual application, a community could enter the plan at any stage and, by taking the outlined Public Sector Actions in previous stages, achieve the desired reduction in demand.

The Emergency Action Team is composed of local government officials including the mayor, city council, utility management, city engineer, and county commissioners. The members of the team would be responsible for assessing the percentage loss in supply capability and then relaying this information to the appropriate County Emergency Services Office. This will activate the emergency network as previously described for the urban communities. In the event of contamination, the North Dakota State Department of Health or the Minnesota Department of Health - Division of Water Supply should also be contacted directly. Since the team also contains the major local officials, it would be appropriate for them to take charge of initiating the other designated Public Sector Actions.

Stage A is implemented when a loss of less than 10 percent of municipal water supply capability is anticipated. In the plan, this loss is mitigated with Public Sector Actions producing a comparable reduction in water demand. After making the appropriate contacts, the Emergency Action Team initiates a public education campaign to explain general water conservation practices and details of the restriction ordinance and retrofit distribution. The water facility maintenance program is also intensified. The water conservation practices, including restrictions and retrofit promotion, are essentially the same as those previously described in the Drought Emergency Plan for the urban core communities. As before, this periodic retrofit promotion is part of the long-term retrofit and installation measure. It takes advantage of the heightened public awareness about conservation to promote the installation of retrofit devices. The same methods of enforcement are also applicable, though

strong voluntary commitment to conservation could be expected under these emergency circumstances. The facilities maintenance programs of the rural communities are simpler than those of the urban core communities. Increased system management activities would consist of additional labor devoted to monitoring meters and nightly sewer flows to detect leaks and then repair them.

Stage B is implemented if a loss of 10 to 20 percent of average annual demand is expected. Argusville and Mapleton can possibly reactivate their older municipal supply systems. Other communities should encourage the use of existing individually owned wells. The emergency status is announced to the public through town meetings or door-to-door visits. Topics of discussion include details of a rationing program or a water use ban and other potential actions if the situation should worsen. Possible rationing programs are discussed in Chapter V and in the Drought Emergency Plan for urban core communities. At this point, a ban on all non-essential water uses could provide the needed reduction. If climatological or other information implies that the water supply shortage will not worsen, this could be a more cost-effective solution. However, if the situation is anticipated to become more severe, introducing rationing at this point would provide a unity to the conservation program. The consumers would become familiar with the program requirements before they became mandatory and, when the situation worsened, the transition to mandatory rationing would be smoother.

Stage C is implemented if losses in supply capability are more than 20 percent. The rural communities must now arrange for trucked-in water from other sources. A door-to-door public education campaign could be used to inform all residents of the necessary conservation measures, including the mandatory rationing program.

XIII. CONCLUSIONS AND RECOMMENDATIONS

This study evaluates water conservation measures for the two groups of study area communities. A combination of measures (conservation proposal) is proposed for the urban core communities of Fargo, Moorhead, West Fargo, and Dilworth and for the remaining rural communities. These two conservation proposals are evaluated considering their economic benefits and costs and environmental and social impacts when they are integrated into the Phase 2 water supply plan. Principal economic benefits include: reduced energy consumption from heating less hot water; savings from deferred, scaled-down, or eliminated capital improvements for water and wastewater facilities; and reduced operation, maintenance, and replacement expenditures from treating and transporting less water. The benefits are offset by economic costs primarily for implementing the conservation measures.

The potential environmental and social impacts of conservation include increased water rates, reduced wastewater return flows, as well as reduced demands on water resources. Potential increases in water rates are the probable results of the implementation of a peak pricing for periods of heavy use. However, the size of this potential increase is site-specific and would need to be determined for each municipality by a separate rate study. Therefore, this effect is not presently quantifiable. If all reductions in municipal water demand related to conservation are used to conserve surface water, slightly higher flows would result. This would reduce the duration of substandard flows and benefit aquatic life.

The following measures were determined to produce a net beneficial NED effect with no significant adverse environmental and social effects.

Measure	Urban Core	Rural
Retrofit Distribution and Installation	X	X
Pricing	X	X
Retrofit Distribution	X	X
Water-Saving Fixtures	X	X
Sprinkling Ordinance	X	
Education	X	X

There are interactions between these measures because several measures affect the same water use or have some common methods of implementation. Therefore, when conservation measures are combined to form a proposal, the subsequent reduction is often less than the sum of the individual reductions. This is true for the economic benefits as well.

Based on evaluations of various combinations of measures, the proposal offering the greatest net benefit was selected for each group of communities. These proposals are outlined below.

Measures	Proposal for Urban Core Communities	Proposal for Rural Communities
Retrofit Distribution and Installation	X	X
Pricing	X	X
Education	X	
Sprinkling Ordinance	X	

By year 2030, the proposal for the urban core is expected to reduce average daily water use by nearly 3.4 mgd (13 percent) and maximum day use by nearly 14 mgd (24 percent). A net economic benefit of more than $1,600,000 annually occurs when this proposal is integrated into the preferred Phase 2 water supply plan.

Benefits include energy and supply cost savings. The short-run cost savings, amounting to $277,100 annually, include foregone chemicals and power expenditures, as well as reduced maintenance and repair costs. Long-run cost

savings include foregone aquifer development and delayed and/or scaled down treatment plant expansions. The sources of water supply for the urban core with the integrated plan are the same as those of the preferred Phase 2 plan without conservation [Alternative VI (SRR)]. However, the inclusion of conservation eliminates the need to expand the existing Red River in-stream reservoir (assuming 450 acre-feet of usable storage can be maintained behind the existing dam) and reduces the amount of water required from the Buffalo Aquifer from 3.80 to 1.68 mgd. The ultimate water treatment capacity is also reduced from 57 to 43 mgd. The West Fargo and the Moorhead Aquifers are still required to yield 1.20 mgd each and the Kragnes Aquifer 0.25 mgd. The water facilities on the Sheyenne River would be essentially the same in both plans.

The long-run cost savings associated with the level of water development in the integrated supply/conservation plan and are $598,600 annually. Additional energy savings, primarily from reduced hot water use, are $924,600 annually. Economic disadvantages, primarily implementation costs, reduce the potential benefits to the urban core communities to approximately $1,630,000 annually.

The best proposal for the rural communities is composed of the retrofit distribution and installation and pricing measures. It is anticipated to reduce their year 2030 average day use by 0.085 mgd (14 percent) and maximum day use by 0.156 mdg (13 percent). This proposal offers a net economic benefit of approximately $30,000 annually when integrated into the preferred Phase 2 plan without conservation. These cost savings are primarily attributable to energy savings from heating less hot water and delayed wastewater treatment plant expansions. The inclusion of education or sprinkling ordinance measures in place of the pricing measure would produce slightly smaller net benefits. In addition, the Cass Rural Water Users Association customers will have much more significant savings from reduced water bills. The impact of these savings is local and not a component of the NED account; therefore, they were not quantified.

Potential environmental and social impacts include increased water rates and reduced wastewater return flows. Potential increases in water rates probably would result from the implementation of a peak pricing measure for periods of heavy use. However, the size of this potential increase is site-specific and would need to be determined for each municipality by a separate rate study. Therefore, this effect is not presently quantifiable.

Conservation could reduce return flows from the urban core communities to area rivers by 2.29 mgd (3.55 cfs) in year 2030. This represents a reduction of only 12 percent in the average return flows, and the associated impacts are anticipated to be minimal.

The integrated water supply/conservation plan is designed to meet the demands of the 50-year drought through the year 2030. Contingent measures (measures not included in the integrated supply/conservation plan) can be used to extend the capability of water facilities to meet more severe droughts. Implementation of selected measures as directed by the Drought Emergency Plans will enable the communities to satisfy demands in droughts more severe than the 100-year event.

The first phase in implementing the integrated water supply/conservation plan would be construction of interconnections between Fargo and West Fargo and between Moorhead and Dilworth. Major components of the next phase, beginning in 1990, include the construction of a connection between Fargo and Moorhead and additional storage facilities for Dilworth, Sabin, and Glyndon. Major capital investments throughout the remainder of the 50-year study period include expansion of the Fargo water treatment plant, two expansions of Moorhead's well facilities, expansion of Moorhead's water treatment facilities, and replacement of equipment in Fargo's water treatment plant.

It is recommended that both the urban core and the rural communities implement the water conservation proposals and take the initial steps to implement the water supply/conservation plan. The rural communities served by CRWUA should also consider the additional benefits due to savings in water bills associated with the integrated water supply/conservation plan.

It is recommended that both urban and rural communities implement the proposed Drought Emergency Plans. These plans help communities to provide an efficient means of dealing with drought shortages or contamination and avoid the hasty and often controversial decisions associated with crisis-oriented responses to drought.

REFERENCES

American Water Works Association. Journal of AWWA. Volume 75, No. 7. AWWA, July 1983.

American Water Works Association. Water Conservation Management. AWWA, 1981.

American Water Works Association. Water Conservation Strategies. AWWA, 1980.

Baumann, Duane D., Bendykt Dziegielewski, John Boland, Chuck Turner. Analytical Bibliography for Water Supply and Conservation Techniques. Fort Belvoir, Virginia: U.S. Army Corps of Engineers, 1982.

Baumann, Duane D., John J. Boland, John H. Sims. The Evaluation of Water Conservation for Municipal and Industrial Water Supply: Procedures Manual. Fort Belvoir, Virginia: U.S. Army Corps of Engineers, 1980.

California Energy Resources Conservation and Development Commission, Conservation Division; The California Appliance Efficiency Program - Revised Staff Report. November 1977.

Flack, J. Ernest, Wade P. Weakley, Duane W. Hill. Achieving Urban Water Conservation - A Handbook. Boulder, Colorado: Colorado Water Resources Research Institute, 1977.

Flack, J. Ernest. "Cutting City Water Demand." Colorado Water Resources Research Institute, Series No. 36.

Flack, J. Ernest. "Residential Water Conservation." Journal of the Water Resources Planning and Management Division, ASCE, 107: pp. 85-95. 1981.

Gardner, Richard L. An Analysis of Residential Water Demand and Water Rates in Minnesota. Minneapolis, Minnesota: Water Resources Research Center - University of Minnesota, 1977.

Gardner, Richard L. "Water and Sewer Rates in Minnesota." Minneapolis, Minnesota: Water Resources Research Center - University of Minnesota, 1977.

Hansen, Zachary J. Water Conservation in the Twin Cities Metropolitan Area. St. Paul, Minnesota: Metropolitan Council of the Twin Cities Area, 1983.

Hitchcock, Henry H., R. Chester Strobel. Analytical Review of Research Reports on the Social Impacts of Water Resources Development Projects. Fort Belvoir, Virginia: U.S.A. Engineer Institute for Water Resources, 1979.

Hitchcock, Henry H. Analytical Review of Research Reports on Social Impacts of Water Resources Development Projects. Washington, D.C.: The George Washington University, 1977.

Howe, Charles W., Paul K. Alexander, JoAnne Goldberg, Steven Sertner, Hans Peter Studer. Drought-Induced Problems and Responses of Small Towns and Rural Water Entities in Colorado: The 1976-1978 Drought. Fort Collins, Colorado: Colorado Water Resources Research Institute, 1980.

Milne, Murray. Residential Water Conservation. Davis, California: California Water Resources Center, Report 35, March 1976. NTIS No. PB-253253.

Minnesota Department of Health. "An Assessment of Minnesota Municipal Water Systems for Conservation Potential." March 1981.

Minnesota Department of Natural Resources. "Minnesota Code of Agency Rules, Department of Natural Resources, Appropriations of Waters." Department of Administration, Office of State Registrar.

"Minnesota State Statutes 105.41, Division of Waters, Soils, and Minerals." St. Paul, Minnesota: Office of State Registrar, Department of Administration.

New England River Basins Commission. Before the Well Runs Dry, A Handbook for Designing a Local Water Conservation Plan. Virginia: U.S. Department of the Interior, Geological Survey, 1981.

New England River Basins Commission. Before the Well Runs Dry: Literature Survey and Analysis of Water Conservation, Volume I. Virginia: U.S. Department of the Interior, Geological Survey, 1980.

New England River Basins Commission Water Supply/Conservation Program. Developing a Drought Emergency Program. Boston, Massachusetts: New England River Basins Commission, 1981.

Richards, William G. and others. Algorithm for Determining the Effectiveness of Water Conservation Measures. NTIS Technical Report EL-84-3. U.S. Army Corps of Engineers, March 1984.

Stone, Brian G. "Suppression of Water Use by Physical Methods." Water Conservation Strategies. AWWA, 1980.

Upper Mississippi River Basin Commission. The Water Conservation Challenge, Symposium Proceedings. Twin Cities, Minnesota: Upper Mississippi River Basin Commission, May 10, 1978.

U.S. Army Corps of Engineers. The Evaluation of Water Conservation for Municipal and Industrial Water Supply. Volume II. Fort Belvoir, Virginia: U.S. Army Corps of Engineers, 1981.

U.S. Water Resources Council. State Water Conservation Planning Guide. Washington, D.C. 1980.

Walski, Thomas M. "Economic Analysis of Rehabilitation of Water Mains." Journal of the Water Resources Planning and Management Division, Proceedings of the ASCE, Vol. 108, No. WR3. October 1982.

APPENDIX A

DISAGGREGATED WATER AND WASTEWATER USE FOR INDIVIDUAL STUDY AREA COMMUNITIES

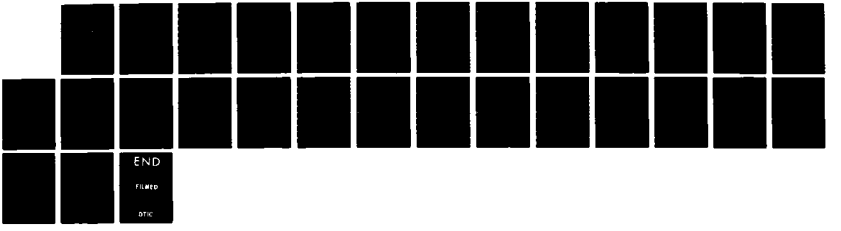
APPENDIX A

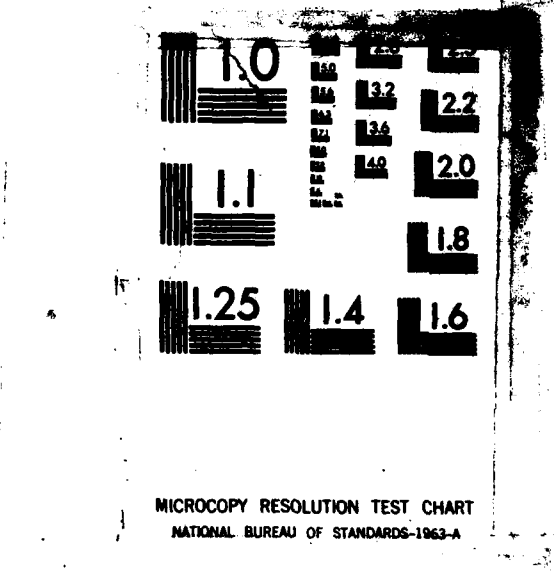
DISAGGREGATED WATER AND WASTEWATER USE FOR INDIVIDUAL STUDY AREA COMMUNITIES

This appendix contains disaggregated water and wastewater use forecasts for individual communities. In these tables, wastewater flow from Riverside is presented by sector and is shown as miscellaneous flow on the summary of disaggregated forecasts for West Fargo. The wastewater flow for Dilworth is presented in the same manner because Moorhead treats its water.

AD-A157 286 FARGO-MOORHEAD URBAN STUDY WATER CONSERVATION APPENDIX 3/3
(U) CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT
MAY 85

UNCLASSIFIED F/G 13/2 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TABLE A-1

SUMMARY OF DISAGGREGATED WATER AND WASTEWATER USE - FARGO
(million gallons per day)

	Projected Water Use						Projected Wastewater Use
	Average Annual Day Use	Maximum Day Use	Seasonal Use	Unaccounted-for and Public	Cooling Water	Total Consumptive Use	Average Day Sewer Construction
Year 2000							
Residential	3.64	17.46	1.32	2.77	--	4.09	3.44
Commercial	4.38	5.25	0.07	0.58	--	0.65	4.54
Industrial	0.87	0.99	0.01	0.03	0.25	0.29	0.62
Miscellaneous (Private Supply)	--	--	--	--	--	--	0.18
Unaccounted-for and Public	3.38	3.92	0.05	--	--	0.05	--
Processing Water	1.23	1.59	--	--	--	--	--
Municipal Totals	13.50	29.21	1.45	3.38	0.25	5.08	8.78
Year 2030							
Residential	4.72	22.00	1.62	3.48	--	5.10	4.35
Commercial	5.61	6.45	0.07	0.83	--	0.90	5.84
Industrial	1.11	2.13	0.11	0.04	0.34	0.49	0.67
Miscellaneous (Private Supply)	--	--	--	--	--	--	0.18
Unaccounted-for and Public	4.35	4.92	0.06	--	--	0.06	--
Processing Water	1.58	2.08	--	--	--	--	--
Municipal Totals	17.37	37.58	1.86	4.35	0.34	6.55	11.04

TABLE A-2

SUMMARY OF DISAGGREGATED WATER AND WASTEWATER USE - MOORHEAD
(million gallons per day)

	Projected Water Use						Projected Wastewater Use
	Average Annual Day Use	Maximum* Day Use	Seasonal Use	Unaccounted-for and Public	Cooling Water	Total Consumptive Use	Average Day Sewer Construction
Year 2000							
Residential	1.93	8.18	0.84	0.39	--	1.23	1.72
Commercial	1.63	1.49	--	0.08	--	0.08	1.76
Industrial	1.70	1.32	--	--	0.18	0.18	1.52
Miscellaneous (Dilworth's Wastewater Flow)	--	--	--	--	--	--	0.22
Unaccounted-for and Public	0.47	0.47	--	--	--	--	--
Municipal Totals	5.73	11.46	0.84	0.47	0.18	1.49	5.22
Year 2030							
Residential	2.16	9.14	0.86	0.43	--	1.29	1.94
Commercial	1.92	1.79	--	0.10	--	0.10	2.07
Industrial	1.83	1.42	--	--	0.19	0.19	1.64
Miscellaneous (Dilworth's Wastewater Flow)	--	--	--	--	--	--	0.29
Unaccounted-for and Public	0.53	0.53	--	--	--	--	--
Municipal Totals	6.44	12.88	0.86	0.53	0.19	1.58	5.94

*The maximum day use is the "maximum municipal day" use. It is assumed to occur in July or August based on historical data. The commercial and industrial demands on that day are less than their respective average day contributions because their respective maximum day demands for these consuming sectors occur during other months.

TABLE A-3

SUMMARY OF DISAGGREGATED WATER AND WASTEWATER USE - WEST FARGO
(million gallons per day)

	Projected Water Use						Projected Wastewater Use
	Average Annual Day Use	Maximum Day Use	Seasonal Use	Unaccounted-for and Public	Cooling Water	Total Consumptive Use	Average Day Sewer Construction
Year 2000							
Residential	0.73	2.75	0.17	0.12	--	0.29	0.880
Commercial	0.53	0.54	--	0.01	--	0.01	0.550
Industrial	0.03	0.03	--	--	--	--	0.030
Miscellaneous (Private Supply)	--	--	--	--	--	--	0.390
(Riverside Wastewater Flow)	--	--	--	--	--	--	0.199
Unaccounted-for and Public	0.13	0.13	--	--	--	--	--
Municipal Totals	1.42	3.45	0.17	0.13	--	0.30	2.049
Year 2030							
Residential	1.05	4.09	0.26	0.18	--	0.44	1.120
Commercial	0.88	0.94	--	0.02	--	0.02	0.920
Industrial	0.04	0.04	--	--	--	--	0.040
Miscellaneous (Private Supply)	--	--	--	--	--	--	0.390
(Riverside Wastewater Flow)	--	--	--	--	--	--	0.248
Unaccounted-for and Public	0.20	0.20	--	--	--	--	--
Municipal Totals	2.17	5.27	0.26	0.20	--	0.46	2.718

TABLE A-4

SUMMARY OF DISAGGREGATED WATER AND WASTEWATER USE - DILWORTH
(million gallons per day)

	Projected Water Use						Projected Wastewater Use
	Average Annual Day Use	Maximum Day Use	Seasonal Use	Unaccounted-for and Public	Cooling Water	Total Consumptive Use	Average Day Sewer Construction
Year 2000							
Residential	0.206	0.435	0.050	0.022	--	0.072	0.198
Commercial	0.023	0.048	0.005	0.003	--	0.008	0.022
Miscellaneous (Private Supply)	--	--	--	--	--	--	--
Unaccounted-for and Public	0.025	0.025	--	--	--	--	--
Municipal Totals	0.254	0.508	0.055	0.025	--	0.080	0.220
Year 2030							
Residential	0.283	0.597	0.068	0.031	--	0.099	0.261
Commercial	0.031	0.066	0.008	0.004	--	0.012	0.029
Miscellaneous (Private Supply)	--	--	--	--	--	--	--
Unaccounted-for and Public	0.035	0.035	--	--	--	--	--
Municipal Totals	0.349	0.698	0.076	0.035	--	0.111	0.290

TABLE A-5

SUMMARY OF DISAGGREGATED WATER AND WASTEWATER USE - GLYNDON
(million gallons per day)

	Projected Water Use						Projected Wastewater Use
	Average Annual Day Use	Maximum Day Use	Seasonal Use	Unaccounted-for and Public	Cooling Water	Total Consumptive Use	Average Day Sewer Construction
Year 2000							
Residential	0.089	0.188	0.031	0.010	--	0.041	0.093
Commercial	0.010	0.021	0.003	0.001	--	0.004	0.011
Miscellaneous (Private Supply)	--	--	--	--	--	--	--
Unaccounted-for and Public	0.011	0.011	--	--	--	--	--
Municipal Totals	0.110	0.220	0.034	0.011	--	0.045	0.104
Year 2030							
Residential	0.095	0.202	0.032	0.011	--	0.043	0.099
Commercial	0.011	0.022	0.004	0.001	--	0.005	0.011
Miscellaneous (Private Supply)	--	--	--	--	--	--	--
Unaccounted-for and Public	0.012	0.012	--	--	--	--	--
Municipal Totals	0.118	0.236	0.036	0.012	--	0.048	0.110

TABLE A-6

SUMMARY OF DISAGGREGATED WATER AND WASTEWATER USE - SABIN
(million gallons per day)

	Projected Water Use						Projected Wastewater Use
	Average Annual Day Use	Maximum Day Use	Seasonal Use	Unaccounted-for and Public	Cooling Water	Total Consumptive Use	Average Day Sewer Construction
Year 2000							
Residential	0.068	0.145	0.021	0.008	--	0.029	0.047
Commercial	0.008	0.016	0.002	0.001	--	0.003	0.006
Miscellaneous (Private Supply)	--	--	--	--	--	--	--
Unaccounted-for and Public	0.009	0.009	--	--	--	--	--
Municipal Totals	0.085	0.170	0.023	0.009	--	0.032	0.053
Year 2030							
Residential	0.101	0.212	0.032	0.011	--	0.043	0.069
Commercial	0.011	0.024	0.004	0.001	--	0.005	0.007
Miscellaneous (Private Supply)	--	--	--	--	--	--	--
Unaccounted-for and Public	0.012	0.012	--	--	--	--	--
Municipal Totals	0.124	0.248	0.036	0.012	--	0.048	0.076

TABLE A-7

SUMMARY OF DISAGGREGATED WATER AND WASTEWATER USE - RIVERSIDE
(million gallons per day)

	Projected Water Use						Projected Wastewater Use
	Average Annual Day Use	Maximum Day Use	Seasonal Use	Unaccounted-for and Public	Cooling Water	Total Consumptive Use	Average Day Sewer Construction
Year 2000							
Residential	0.032	0.069	0.001	0.005	--	0.006	0.038
Commercial	0.003	0.006	--	--	--	--	0.004
Industrial	0.012	0.024	--	--	--	--	0.012
Miscellaneous (Private Supply-Cargill)	--	--	--	--	--	--	0.145
Unaccounted-for and Public	0.005	0.005	--	--	--	--	--
Municipal Totals	0.052	0.104	0.001	0.005	--	0.006	0.199
Year 2030							
Residential	0.032	0.070	0.001	0.006	--	0.007	0.038
Commercial	0.003	0.006	--	--	--	--	0.004
Industrial	0.024	0.048	--	--	--	--	0.024
Miscellaneous (Private Supply-Cargill)	--	--	--	--	--	--	0.182
Unaccounted-for and Public	0.006	0.006	--	--	--	--	--
Municipal Totals	0.065	0.130	0.001	0.006	--	0.007	0.248

TABLE A-8

SUMMARY OF DISAGGREGATED WATER AND WASTEWATER USE - HARWOOD
(million gallons per day)

	Projected Water Use						Projected Wastewater Use
	Average Annual Day Use	Maximum Day Use	Seasonal Use	Unaccounted-for and Public	Cooling Water	Total Consumptive Use	Average Day Sewer Construction
Year 2000							
Residential	0.044	0.093	0.004	0.005	--	0.009	0.058
Commercial	0.005	0.010	0.001	--	--	0.001	0.006
Miscellaneous (Private Supply)	--	--	--	--	--	--	--
Unaccounted-for and Public	0.005	0.005	--	--	--	--	--
Municipal Totals	0.054	0.108	0.005	0.005	--	0.010	0.064
Year 2030							
Residential	0.060	0.128	0.004	0.008	--	0.012	0.075
Commercial	0.007	0.014	0.001	--	--	0.001	0.008
Miscellaneous (Private Supply)	--	--	--	--	--	--	--
Unaccounted-for and Public	0.008	0.008	--	--	--	--	--
Municipal Totals	0.075	0.150	0.005	0.008	--	0.013	0.083

TABLE A-9

SUMMARY OF DISAGGREGATED WATER AND WASTEWATER USE - HORACE
(million gallons per day)

	Projected Water Use						Projected Wastewater Use
	Average Annual Day Use	Maximum Day Use	Seasonal Use	Unaccounted-for and Public	Cooling Water	Total Consumptive Use	Average Day Sewer Construction
Year 2000							
Residential	0.029	0.062	0.002	0.004	--	0.006	0.041
Commercial	0.003	0.006	--	--	--	--	0.005
Miscellaneous (Private Supply)	--	--	--	--	--	--	--
Unaccounted-for and Public	0.004	0.004	--	--	--	--	--
Municipal Totals	0.036	0.072	0.002	0.004	--	0.006	0.046
Year 2030							
Residential	0.048	0.102	0.004	0.006	--	0.010	0.060
Commercial	0.005	0.010	--	--	--	--	0.007
Miscellaneous (Private Supply)	--	--	--	--	--	--	--
Unaccounted-for and Public	0.006	0.006	--	--	--	--	--
Municipal Totals	0.059	0.118	0.004	0.006	--	0.010	0.067

TABLE A-10

SUMMARY OF DISAGGREGATED WATER AND WASTEWATER USE - MAPLETON
(million gallons per day)

	Projected Water Use						Projected -- Wastewater Use --
	Average Annual Day Use	Maximum Day Use	Seasonal Use	Unaccounted-for and Public	Cooling Water	Total Consumptive Use	Average Day Sewer Construction
Year 2000							
Residential	0.024	0.049	0.002	0.002	--	0.004	0.022
Commercial	0.002	0.005	--	--	--	--	0.002
Miscellaneous (Private Supply)	--	--	--	--	--	--	--
Unaccounted-for and Public	0.002	0.002	--	--	--	--	--
Municipal Totals	0.028	0.056	0.002	0.002	--	0.004	0.024
Year 2030							
Residential	0.046	0.096	0.003	0.005	--	0.008	0.043
Commercial	0.005	0.011	--	--	--	--	0.005
Miscellaneous (Private Supply)	--	--	--	--	--	--	--
Unaccounted-for and Public	0.005	0.005	--	--	--	--	--
Municipal Totals	0.056	0.112	0.003	0.005	--	0.008	0.048

TABLE A-11

SUMMARY OF DISAGGREGATED WATER AND WASTEWATER USE - ARGUSVILLE
(million gallons per day)

	Projected Water Use						Projected Wastewater Use
	Average Annual Day Use	Maximum Day Use	Seasonal Use	Unaccounted-for and Public	Cooling Water	Total Consumptive Use	Average Day Sewer Construction
Year 2000							
Residential	0.008	0.017	--	0.001	--	0.001	0.008
Commercial	0.001	0.002	--	--	--	--	0.001
Miscellaneous (Private Supply)	--	--	--	--	--	--	--
Unaccounted-for and Public	0.001	0.001	--	--	--	--	--
Municipal Totals	0.010	0.020	--	0.001	--	0.001	0.009
Year 2030							
Residential	0.008	0.017	--	0.001	--	0.001	0.008
Commercial	0.001	0.002	--	--	--	--	0.001
Miscellaneous (Private Supply)	--	--	--	--	--	--	--
Unaccounted-for and Public	0.001	0.001	--	--	--	--	--
Municipal Totals	0.010	0.020	--	0.001	--	0.001	0.009

TABLE A-12

DISAGGREGATED WATER USE - CASS RURAL COMMUNITIES WITHOUT WASTEWATER TREATMENT FACILITIES
(mgd)

Community	Year 2000 Average Day Use	Year 2000 Maximum Day Use	Year 2000 Seasonal Use	Year 2000 Consumptive Use	Year 2030 Average Day Use	Year 2030 Maximum Day Use	Year 2030 Seasonal Use	Year 2030 Consumptive Use
Frontier	0.012	0.024	0.001	0.001	0.014	0.028	0.001	0.001
North River	0.008	0.016	0.001	0.001	0.018	0.036	0.002	0.002
Briarwood	0.006	0.012	0.001	0.001	0.006	0.012	0.001	0.001
Total	0.026	0.052	0.003	0.003	0.038	0.076	0.004	0.004

DISAGGREGATED WATER USE - INDIVIDUAL SYSTEMS
(mgd)

Community	Year 2000 Average Day Use	Year 2000 Maximum Day Use	Year 2000 Seasonal Use	Year 2000 Consumptive Use	Year 2030 Average Day Use	Year 2030 Maximum Day Use	Year 2030 Seasonal Use	Year 2030 Consumptive Use
Reile's Acres	0.013	0.026	0.001	0.001	0.013	0.026	0.001	0.001
Prairie Rose	0.011	0.022	0.001	0.001	0.025	0.500	0.002	0.002
Rustad	0.004	0.008	--	--	0.004	0.008	--	--
Kragnes	0.003	0.006	--	--	0.003	0.006	--	--
Total	0.031	0.062	0.002	0.002	0.045	0.090	0.003	0.003

NOTE: All use is assumed to be residential.

Approximately 10 percent of the average day use is assumed to be seasonal use based on results of other communities.

APPENDIX B

DETAILED IMPACTS OF WATER CONSERVATION PROPOSALS

EFFECTS ON WATER USE AND SEWER FLOWS
ENERGY SAVINGS
IMPLEMENTATION COSTS
SUMMARY OF FOREGONE SUPPLY COST SAVINGS

APPENDIX B

DETAILED IMPACTS OF WATER CONSERVATION PROPOSALS

This appendix contains tables of data generated in order to arrive at the net beneficial NED effect for the conservation proposals. These tables are presented in pairs; the first table for urban core and the second for the rural communities. Tables B-1 and B-2 list the effects on water use and sewer flows for each proposal for each dimension of water use. Tables B-3 and B-4 show detailed energy costs for each proposal. Tables B-5 and B-6 itemize implementation costs and Tables B-7 and B-8 summarize the components of foregone supply cost savings for each proposal.

TABLE B-1

EFFECT OF TRIAL PROPOSALS ON WATER USE AND SEWER FLOWS - URBAN CORE COMMUNITIES
- flow in mgd -

Conservation Proposal Measures	Year 2000 Seasonal Use	Year 2000 Average Day Use	Year 2000 Maximum Day Use	Year 2000 Consumptive Use	Year 2000 Average Day Sewer Contribution	Year 2030 Seasonal Use	Year 2030 Average Day Use	Year 2030 Maximum Day Use	Year 2030 Consumptive Use	Year 2030 Average Day Sewer Contribution
Trial Proposal 1	2.515	19.596	43.320	6.900	14.961	3.056	24.627	54.726	8.641	18.286
Retrofit Distribution and Installation		(1.308)	(1.308)		(1.308)		(1.702)	(1.702)		(1.702)
Trial Proposal 2	2.325	19.066	39.52	6.71	14.621	2.833	23.964	50.066	8.418	17.846
Retrofit Distribution and Installation	(0.190)	(1.838)	(5.108)	(0.190)	(1.648)	(0.223)	(2.365)	(6.362)	(0.223)	(2.142)
Pricing										
Trial Proposal 3	---------- (Same effectiveness as Trial Proposal 2) ----------									
Retrofit Distribution and Installation										
Pricing										
Retrofit Distribution										

TABLE B-1 (continued)

EFFECT OF TRIAL PROPOSALS ON WATER USE AND SEWER FLOWS - URBAN CORE COMMUNITIES
- flow in mgd -

Conservation Proposal Measures	Year 2000 Seasonal Use	Year 2000 Average Day Use	Year 2000 Maximum Day Use	Year 2000 Consumptive Use	Year 2000 Average Day Sewer Contribution	Year 2030 Seasonal Use	Year 2030 Average Day Use	Year 2030 Maximum Day Use	Year 2030 Consumptive Use	Year 2030 Average Day Sewer Contribution
Trial Proposal 4	2.175	18.800	37.842	6.560	14.505	2.657	23.637	48.014	8.242	17.695
	(0.340)	(2.104)	(6.786)	(0.340)	(1.764)	(0.399)	(2.692)	(8.414)	(0.399)	(2.293)
	(Interaction factor of education with retrofit measure is 0.789)									
Retrofit Distribution and Installation										
Pricing										
Education										
Trial Proposal 5	2.175	18.783	37.824	6.560	14.487	2.657	23.576	47.953	8.242	17.634
	(0.340)	(2.122)	(6.804)	(0.340)	(1.782)	(0.399)	(2.753)	(8.475)	(0.399)	(2.354)
	(Interaction of water-saving fixtures with retrofit measure is 0.10)									
Retrofit Distribution and Installation										
Pricing										
Education										
Water-Saving Fixtures										
Trial Proposal 6	1.587	18.212	32.824	5.972	14.505	1.979	22.959	42.811	7.564	17.695
	(0.928)	(2.692)	(11.804)	(0.928)	(1.764)	(1.077)	(3.370)	(13.617)	(1.077)	(2.293)
Retrofit Distribution and Installation										
Pricing										
Education	(Total interaction factor of sprinkling with pricing and education measures is 0.75. Five percent of the 25 percent reduction is attributable to education and the remainder to pricing.)									

TABLE B-2

EFFECT OF TRIAL PROPOSALS ON WATER USE AND SEWER FLOWS - RURAL COMMUNITIES
- flow in mgd -

Conservation Proposal Measures	Year 2000 Seasonal Use	Year 2000 Average Day Use	Year 2000 Maximum Day Use	Year 2000 Consumptive Use	Year 2000 Average Day Sewer Contribution	Year 2030 Seasonal Use	Year 2030 Average Day Use	Year 2030 Maximum Day Use	Year 2030 Consumptive Use	Year 2030 Average Day Sewer Contribution
Trial Proposal 1	0.072	0.384	0.816	0.109	0.261	0.092	0.529	1.119	0.142	0.344
	(0.048)	(0.048)	(0.048)		(0.039)		(0.061)	(0.061)		(0.049)
Retrofit Distribution and Installation										
Trial Proposal 2	0.067	0.366	0.745	0.104	0.249	0.086	0.505	1.024	0.136	0.328
	(0.005)	(0.066)	(0.119)	(0.005)	(0.051)	(0.006)	(0.085)	(0.156)	(0.006)	(0.065)
Retrofit Distribution and Installation										
Pricing										
Trial Proposal 3	---------- (Same effectiveness as Trial Proposal 2) ----------									
Retrofit Distribution and Installation										
Pricing										
Retrofit Distribution										

TABLE B-2 (continued)

EFFECT OF TRIAL PROPOSALS ON WATER USE AND SEWER FLOWS - RURAL COMMUNITIES
- flow in mgd -

Conservation Proposal Measures	Year 2000 Seasonal Use	Year 2000 Average Day Use	Year 2000 Maximum Day Use	Year 2000 Consumptive Use	Year 2000 Average Day Sewer Contribution	Year 2030 Seasonal Use	Year 2030 Average Day Use	Year 2030 Maximum Day Use	Year 2030 Consumptive Use	Year 2030 Average Day Sewer Contribution
Trial Proposal 4	0.067	0.365	0.744	0.104	0.248	0.086	0.502	1.021	0.136	0.326
	(0.005)	(0.067)	(0.120)	(0.005)	(0.052)	(0.006)	(0.088)	(0.159)	(0.006)	(0.067)
	(Interaction of water-saving fixtures with retrofit measure is 0.10)									
Retrofit Distribution and Installation Proposal										
Trial Proposal 5	0.063	0.356	0.712	0.072	0.132	0.081	0.491	0.977	0.131	0.0321
	(0.009)	(0.076)	(0.152)	(0.037)	(0.168)	(0.011)	(0.099)	(0.203)	(0.011)	(0.072)
	(Interaction factor of education with retrofit measure is 0.789)									
Retrofit										
Retrofit Distribution and Installation										
Pricing										
Retrofit Distribution Proposal										

TABLE B-3

ENERGY SAVINGS FOR EACH CONSERVATION PROPOSAL

Conservation Proposal	Urban Core Communities			
	Hot Water Savings (mgy)	Gas (10^3 ccf/yr)	Electric (10^3 kwh/yr)	Uniform Annual Savings ($/yr)
Trial Proposal 1	173.94	882.0	13,800.0	640,800
Trial Proposal 2	218.91	1110.0	17,390.0	851,600
Trial Proposal 3	218.91	1110.0	17,390.0	851,600
Trial Proposal 4	234.39	1188.0	18,629.0	924,600
Trial Proposal 5	240.63	1220.0	19,127.0	932,500
Trial Proposal 6	234.39	1188.0	18,629.0	924,600

NOTE: 40 percent of hot water heaters are electric.

60 percent of hot water heaters are gas.

Estimated thermal efficiencies: Gas - 0.79; Electric - 0.98.

Hot water, gas, and electric savings listed are for the year 2030.

TABLE B-4

ENERGY SAVINGS FOR EACH CONSERVATION PROPOSAL

Conservation Proposal	Rural Communities			
	Hot Water Savings (mgy)	Gas (10^3 ccf/yr)	Electric (10^3 kwh/yr)	Uniform Annual Savings ($/yr)
Trial Proposal 1	5.93	30.0	470.0	25,400
Trial Proposal 2	7.74	38.9	610.0	35,300
Trial Proposal 3	7.74	38.9	610.0	35,300
Trial Proposal 4	8.00	40.2	630.0	35,600
Trial Proposal 5	8.35	41.8	660.0	38,200

NOTE: 40 percent of hot water heaters are electric.

60 percent of hot water heaters are gas.

Estimated thermal efficiencies: Gas - 0.79; Electric - 0.98.

Hot water, gas, and electric savings listed are for the year 2030.

TABLE B-5

SUMMARY OF IMPLEMENTATION COSTS
(UNIFORM ANNUAL COST, $)

Conservation Proposal	Urban Core Communities			
	Local Government Costs	Utility Costs	Water User Costs	Total Costs
Trial Proposal 1	$ --	$142,200	$ --	$142,200
Trial Proposal 2	5,800	146,700	--	152,500
Trial Proposal 3	5,800	146,700	--	152,500
Trial Proposal 4	21,000	146,700	--	167,700
Trial Proposal 5	23,800	146,700	20,700	191,200
Trial Proposal 6	23,500	146,700	--	170,200

TABLE B-6

SUMMARY OF IMPLEMENTATION COSTS
(UNIFORM ANNUAL COST, $)

Conservation Proposal	Rural Communities			
	Local Government Costs	Utility Costs	Water User Costs	Total Costs
Trial Proposal 1	$ --	$ 6,000	$ --	$ 6,000
Trial Proposal 2	200	9,800	--	10,000
Trial Proposal 3	200	9,800	--	10,000
Trial Proposal 4	300	9,800	700	10,800
Trial Proposal 5	200	13,600	--	13,800

TABLE B-7

SUMMARY OF FOREGONE SUPPLY COST SAVINGS - URBAN CORE COMMUNITIES

Cost Component	Trial Proposal No. 1	Trial Proposal No. 2	Trial Proposal No. 3	Trial Proposal No. 4	Trial Proposal No. 5	Trial Proposal No. 6
Short-Run Incremental Costs						
Water Treatment Plant, Supply and Distribution	$69,900	$98,000	$98,000	$112,000	$113,000	$247,100
Wastewater Treatment Plant	22,100	27,900	27,900	30,000	30,200	30,000
Long-Run Incremental Costs						
WTP Expansion	22,100	60,500	60,500	70,100	73,200	326,300
Aquifer Expansion	19,600	25,700	25,700	27,800	28,200	33,400
Low-Head Dam Expansion	8,600	8,600	8,600	8,600	8,600	10,700
WWTP Expansions(2)	188,100	224,900	224,900	228,200	234,300	228,200
Total Annual Savings	$330,400	$445,600	$445,600	$476,700	$487,500	$875,700

(1)Fargo and West Fargo only.

TABLE B-8

SUMMARY OF FOREGONE SUPPLY COST SAVINGS - RURAL COMMUNITIES

	Trial Proposal No. 1	Trial Proposal No. 2	Trial Proposal No. 3	Trial Proposal No. 4	Trial Proposal No. 5
Long-Run Incremental Costs					
- WWTP Expansion	$3,500	$4,400	$4,400	$4,400	$4,700
Short-Run Incremental Costs					
- Power	300	400	400	500	500
Total Annual Savings	$3,800	$4,800	$4,800	$4,900	$5,200

APPENDIX C

U.S. ARMY CORPS OF ENGINEERS' SOCIAL ACCEPTABILITY QUESTIONNAIRE

U.S. ARMY CORPS OF ENGINEERS
SOCIAL ACCEPTABILITY QUESTIONNAIRE

The U.S. Army Corps of Engineers has conducted a social acceptability survey of the Fargo-Moorhead study area. The purpose of the survey was to assess the perceptions of area residents about water conservation. A questionnaire (copy attached) addressing specific aspects of common types of water conservation measures was mailed and the replies were evaluated.

The questionnaire was modeled after one in The Evaluation of Water Conservation for Municipal and Industrial Water Supply (OMB 49RO 363). It consisted of a Lickert scale on which respondents evaluated seven separate water conservation methods in terms of perceived qualities (personal knowledge, effectiveness, economic effectiveness, severity to implement, and overall evaluation). The questionnaire also gathered information on the respondents' age, sex, education, and location.

The questionnaire was distributed as a mailed package consisting of a cover letter, questionnaire, address page, and return mailing envelope. The initial distribution was preceded by a press release to area newspapers, informing readers of the questionnaire, its source, and purpose. No direct contact was made on the initial distribution.

The first mailing went to the first 200 parties on the random sample survey. Of the 200 questionnaires mailed, 22 failed to reach the intended respondent, resulting in a net mailing of 178. Of these, 63 usable replies were received.

A second distribution of the same package was in the form of a follow-up mailing to the 115 deliverable nonrespondents and an initial mailing to 22 parties from the backup mailing list to replace the nondeliverables of the first distribution. In the second distribution, only four packages failed to reach

the intended respondent. Thirty-one usable replies were received, bringing the response total to 94 (47 percent), or 26 below the 120 (60 percent) required by the scope of work.

At the stipulation of the contracting officer, the final distribution involved telephone contacts with the remaining nonrespondents on the mailing list. A total of 52 individual telephone calls were made over a 3-week period. Persons contacted were asked to respond and to mail the questionnaire, address page, and return mailing envelope. Thirty-five commitments to respond were elicited, resulting in an additional 27 usable responses. These responses brought the total to 121 usable responses, or a 60.5 percent response rate.

DIRECTIONS: From the left side of the paper, several ways of conserving water are described. Please tell us your reactions to each of them by answering the 5 questions asked across the top of the page. For example, read the description of Conservation Measure A, and then answer all 5 questions about it by checking that one of the 4 spaces under each question that best expresses your opinion. When finished, please fill out the background information and then return the questionnaire to us in the enclosed postage-paid envelope. We are most grateful for your cooperation.

	Question 1: How much do you know about this particular water conservation measure?				Question 2: How well do you think it would work?				Question 3: How economical do you think it would be?				Question 4: How serious would the need for water conservation have to be before you think this measure should be adopted?				Question 5: Over-all, how do you evaluate this conservation measure?			
	know nothing	know just a little	know fair amount	know quite a bit	wouldn't save any water	would save only a very little water	would save a fair amount of water	would save a lot of water	it would cost more than it would be worth	probably come out even, it would cost as much as it would save	it would result in saving some money	it would result in big savings	very serious	moderately serious	slightly serious	not at all serious	it is totally unacceptable	not too good, I don't approve	pretty good, I approve	excellent, I enthusiastically approve
CONSERVATION MEASURES																				
A. Individuals install new water-conserving plumbing fixtures such as low-flow toilets and shower heads in their homes.																				
B. City and state governments engage in active campaigns to educate the public on how to conserve water.																				
C. Sewage is processed and the treated water reused for manufacturing and irrigation of crops.																				
D. Building codes require the installation in new buildings of water-conserving plumbing fixtures such as low-flow shower heads and toilets.																				
E. As the amount of water used increases the price per gallon is raised.																				
F. The use of water for lawn and garden is reduced by half.																				
G. During a severe drought, the government imposes restrictions of water use that if violated result in stiff fines.																				

To be effective, some of the measures described above would have to be made into law and enforced by government. Generally, how would you feel about this? (Please check one)

I would be strongly opposed	I would be somewhat opposed	I would be somewhat in favor	I would be strongly in favor
_____	_____	_____	_____

BACKGROUND INFORMATION

Age: ____ Sex: ____ Occupation: _____

Highest level of schooling completed:

____no formal	____7th grade	____1 year of college
____1st grade	____8th grade	____2 years of college
____2nd grade	____9th grade	____3 years of college
____3rd grade	____10th grade	____4 years of college
____4th grade	____11th grade	____5 years of college
____5th grade	____12th grade	____6 years of college
____6th grade	____G.E.D.	____7 years of college
		____8 years of college
		____Other _____

END

FILMED

9-85

DTIC